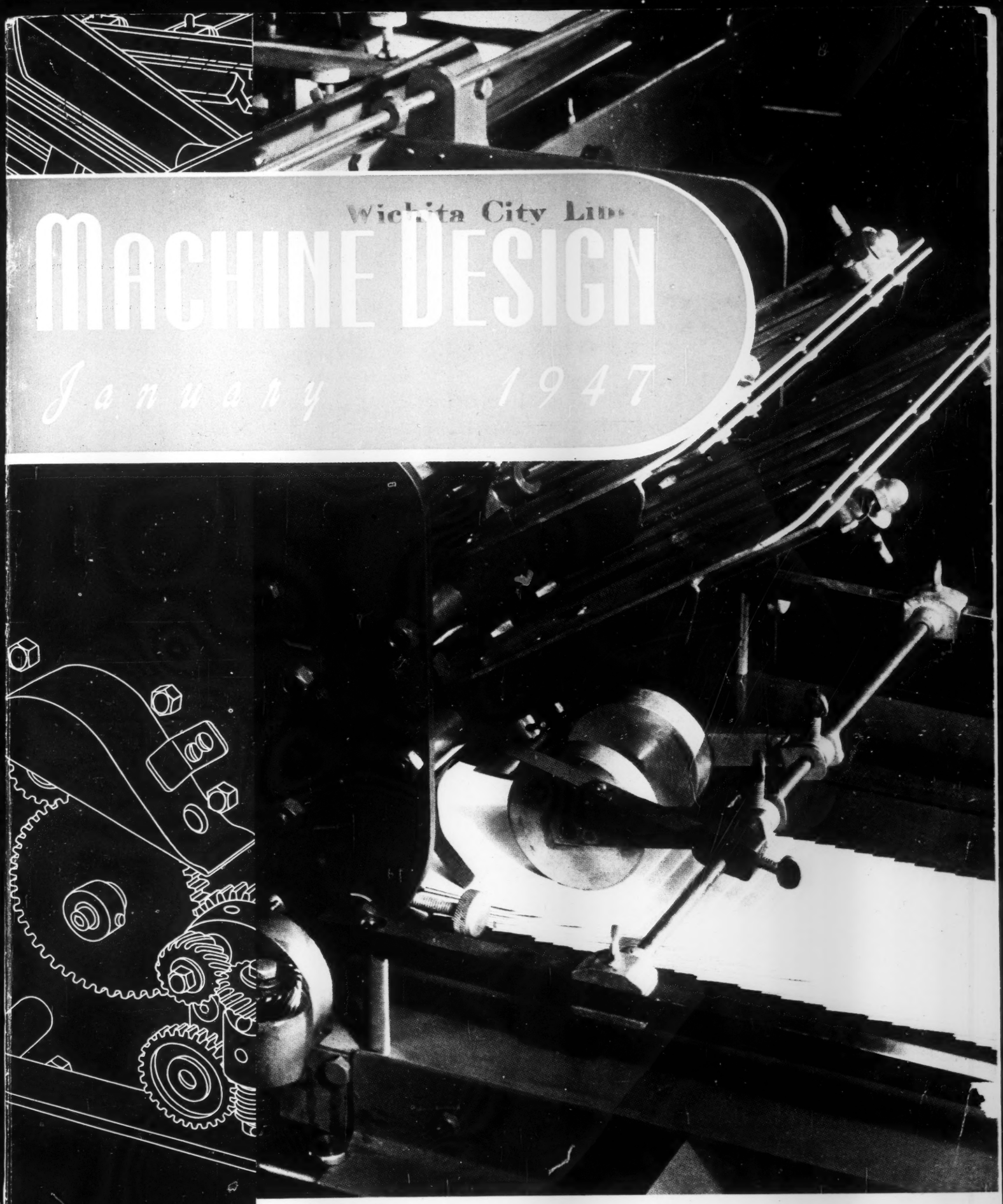

Wichita City Lib

MACHINE DESIGN

January 1947

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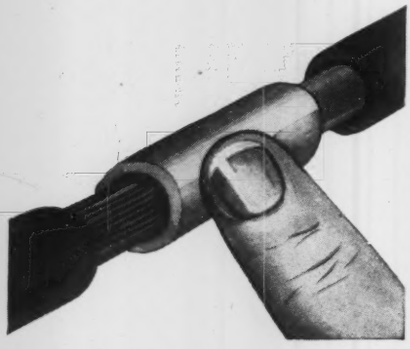
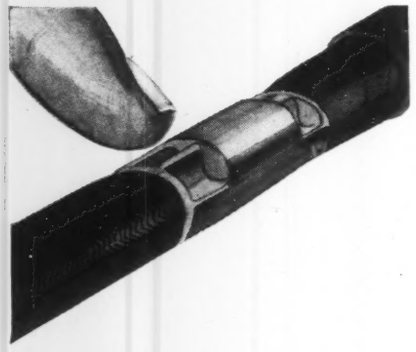
BEAM DEFLECTIONS

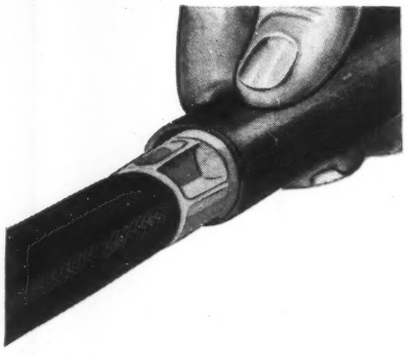
PROJECTION DRAWING



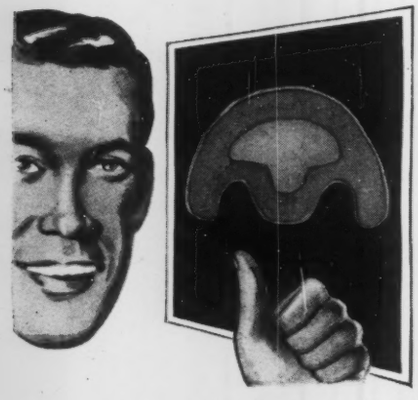
Yes, It's A New Method now used on many of our motors to make winding connections *uniform,* mechanically and electrically. How it works: First, we remove insulating varnish from wire ends by a special process. The bright wire ends are then slipped into this tinned-copper connector. There's no twisting, scraping, unnecessary bending.



Then . . . With A Special Tool, we compress — actually "bond" together — each wire and connector into a homogeneous mass. Every connection is precisely the same as every other . . . no brazing or soldering is used . . . no chance to weaken wires or damage insulation. Wires can't pull out or break-off.



Finally . . . We Slip A Tough, flexible plastic protective tubing over the complete connection. Result: when stator windings are impregnated with insulating varnish and baked out, every connection is uniformly sealed and insulated . . . making a stronger . . . more compact and efficient job . . . another factor demonstrating A-C quality.



Here's An Actual Cross Section microphoto that shows, better than I can tell you, just what happens inside the connection itself. Notice how connector and wires are "bonded" into a single mass. Every connection has precisely the same electrical capacity, assuring balanced phasing.

A-C Builds "Quality" Into Motors

YES, PAYING ATTENTION to details like this new, improved connection contributes importantly toward greater reliability, better performance in motors. Next time you want *good* motors, liberally designed, and with an earned reputation for standing up year after year under toughest operating conditions, specify "Allis-Chalmers". For the complete story call your nearby A-C motor dealer or A-C sales office. ALLIS-CHALMERS, MILWAUKEE 1, WIS.

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One of the Big 3 in Electric Power Equipment — Biggest of All in Range of Industrial Products

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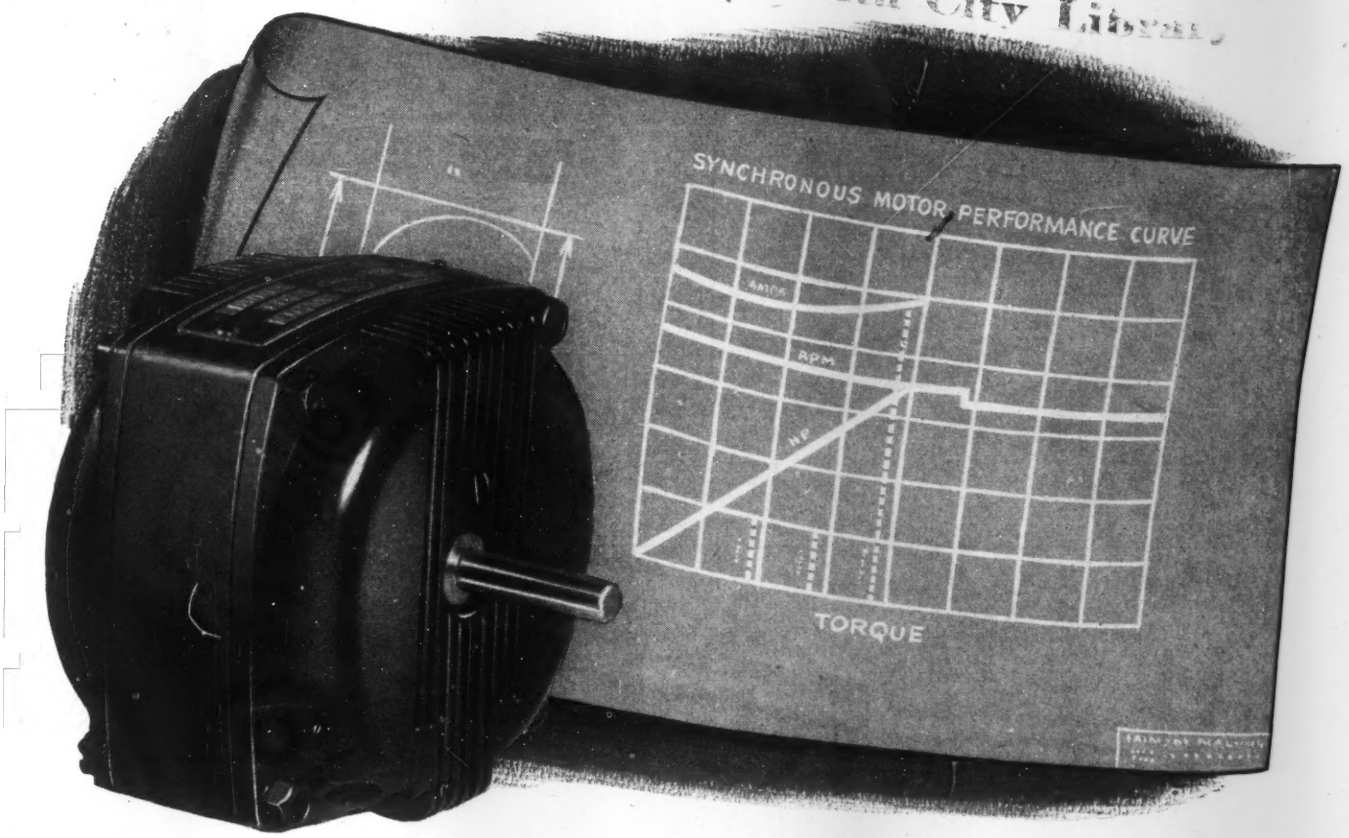


Motors that SOLVE DESIGN PROBLEMS

When designs for a new device are being developed, selection of the correct motor for the application should not be neglected. For best results the motor should be chosen during development, just as gear sizes, operating sequence, or other details are settled before selection of color or exterior details is made.

Bodine application engineers have helped many manufacturers select the right motor to match operating characteristics. For example, the Type K motor shown above is widely used in applications where low power is required in small mounting space. Only 2⅜ inches square, this motor is made in synchronous and non-synchronous types, either with or without integral speed reducer.

If you are designing a unit requiring fractional horsepower motor drive, ask Bodine application engineers to assist you in selecting the motor to operate it. Bodine Electric Co., 2258 West Ohio Street, Chicago 12, Illinois.

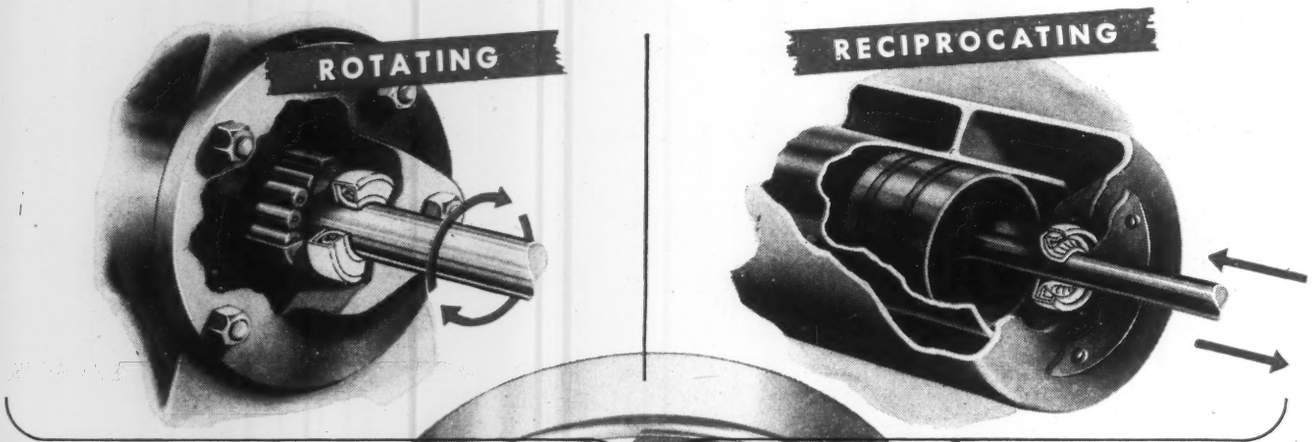
TYPICAL APPLICATION

Submarine Signal Company's Fathometer, widely used by sailing ships, cargo carriers, tankers, luxury liners, yachts, and fishing vessels, is operated by a Bodine Type K speed-reducer motor.

The unique Fathometer is used by all types of vessels to indicate the instantaneous depth of the water over which the ship is passing. By means of this instrument, navigators can tell the location of obstructions under water, and even use the indications to find exact location of the boat in bad weather. Fishing boats often use it to locate schools of fish.

BODINE *FRACTIONAL HORSEPOWER MOTORS*

The Simple Effective Way to Seal Shafts



"PERFECT" *Oil Seals*

PATENTED

THEY DO:	THEY DO NOT:
1—Retain lubricant	1—Permit entrance of foreign matter
2—Prolong bearing life	2—Need adjustment or attention
3—Reduce bearing maintenance	3—Rotate with the shaft
4—Use little space	4—Wick lubricant away from bearing
5—Cost very little	5—Score the shaft

Consult Chicago Rawhide Engineers for Specific Application Information

25

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This Month's Cover: Machine for folding paper, designed by R. E. Olson Folding Machine Co., utilizes neoprene covering for folding rollers and new design cross-carrier with positive hold-down to produce right angle folds on small sheets at high speeds.

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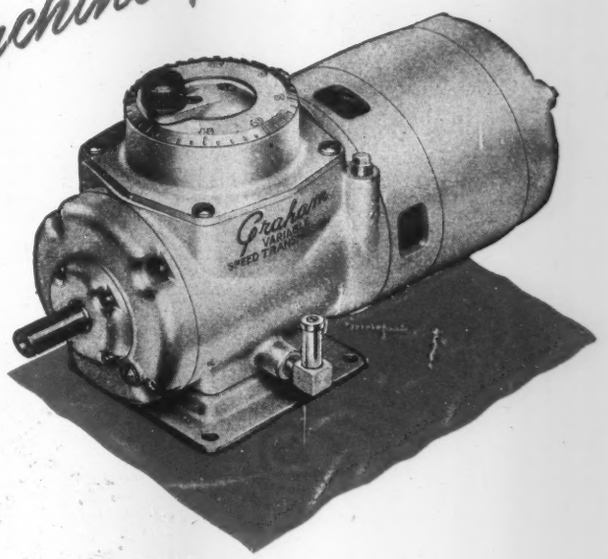

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With Graham prices reduced more than half, you need no longer handicap your machine by limited speed range. *Graham gives every speed from top to zero* — the only variable speed drive built as a straight line extension of a standard induction motor. The complete unit needs no more fastenings than a single speed motor — the ultimate in compactness. Performance proved by eight years use as standard equipment on leading machines.

Model 40 (for 1/4 H.P. to 3/4 H.P. motors) and Model 15 (up to 1/8 H.P.) available with or without motor — see table at right — or with built-in parallel shaft or right angle gear boxes, reduction or step-up. Wide choice of controls — manual, remote, single turn, lever, or micrometer.

These two new drives are specially designed to modernize low horsepower machines that must be sold competitively. Write for Bulletin 508 with prices and delivery. See our catalog in Sweet's File for Product Engineers.

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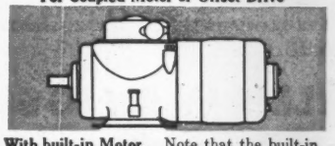
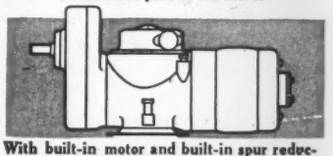
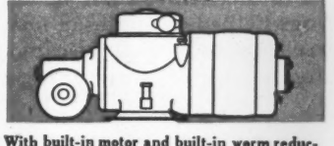


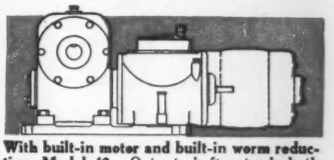
With built-in Motor. Note that the built-in motor is especially designed to form an integral streamlined part of the drive.



With built-in motor and built-in spur reduction or step-up



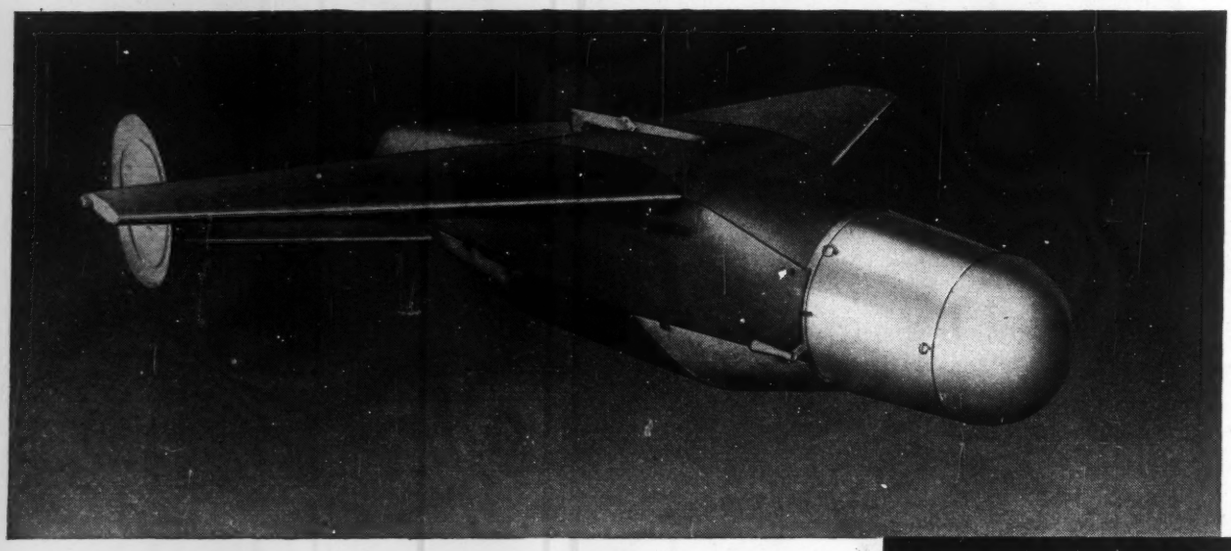
With built-in motor and built-in worm reduction, Model 15. Output shaft may extend horizontally to either side, or vertically up or down. Additional ratios available — 6:1, 10:1, 15:1, 30:1, and 60:1.



With built-in motor and built-in worm reduction, Model 40. Output shaft extends both sides horizontally. Additional ratios available — 9:1, 12:1, 18:1, 36:1 and 47:1.

Model	Input Speed	Output Speed Range	In Lbs. Torque Rating: At Max. Speed	In Lbs. Torque Rating: At Min. Speed	Approx. Ins. Overall Dimensions: Lgth. incl. shaft ext.	Approx. Ins. Overall Dimensions: Width	Approx. Ins. Overall Dimensions: Height	Motor H.P.
15	3600	1100/0	3.5	7.5	8 1/4	4 5/8	5 5/8	1/8 to 1/4
40	3600	1100/0	30	60	13 3/4	7	8	1/4 to 3/4
15M	3600	1100/0	3.5	7.5	11 1/2	4 5/8	5 5/8	1/8 to 1/4
40M	3600	1100/0	30	60	19 1/2	7	8	1/4 to 3/4
15MR5	3600	220/0	15	35	13	4 5/8	6 3/4	1/8 to 1/4
40MR5	3600	220/0	140	280	22	7	10	1/4 to 3/4
40MR2.8	3600	400/0	80	160	22	7	10	1/4 to 3/4
15MS2.5	3600	2750/0	1.3	2.8	13	4 5/8	6 3/4	1/8 to 1/8
40MS2.8	3600	3100/0	10	20	22	7	10	1/4 to 3/4
15MW20	3600	55/0	35	75	12 3/4	4 5/8	5 5/8	1/8 to 1/4
15MW40	3600	28/0	60	120	12 3/4	4 5/8	5 5/8	1/8 to 1/4
40MW6	3600	190/0	120	250	24	8 1/2	10 1/2	1/4 to 3/4
40MW24	3600	46/0	420	840	24	8 1/2	10 1/2	1/4 to 3/4
40MW60	3600	19/0	800	1700	24	8 1/2	10 1/2	1/4 to 3/4

The secret weapon no Jap ship could dodge



Story of the NAVY BAT*. . .

Could a way be found to penetrate enemy anti-aircraft fire . . . and blow each Jap ship to bits . . . *without* losing our pilots?

That was the urgent question. And American genius answered with the Navy Bat—a radar-guided glider bomb.

Designed to glide silently at 300 miles per hour—with a 1,000-pound bomb in its belly—the Bat was carried by a Navy patrol bomber.

At a point five miles from the target, the "mother" plane would aim the Bat at a Jap ship and release it. From then on the Bat automatically followed every twist or turn of the enemy ship—and smashed into the dodging Jap.

Used against Jap destroyers, tankers, picket boats—and land installations—this weapon was so effective the enemy thought we had a suicide pilot inside each Bat.

Instead, the Bat contained revolving radar gear to search for the target —and tiny gyroscopes to correct for errors in flight.

"Mother" plane—five miles from target—aims the Bat, releases it, and turns away from enemy anti-aircraft fire. Bat glides ahead.

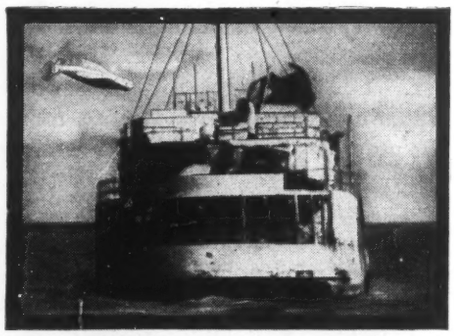
. . . and its 36 BALL BEARINGS

The men who developed this marvel knew that every Bat had to hit its target. They designed special guiding mechanisms. They made them sturdy, trouble-free, delicately responsive. They mounted the moving parts in 36 BALL BEARINGS.

New Departure ball bearings can be mounted in any position. They hold moving parts precisely in place—with unchanging accuracy—under every kind of load. They move with less friction than any other type of anti-friction bearing.

In the Bat—and in many other kinds of mechanized war materiel—375 million New Departure ball bearings helped our fighting men.

Today, millions more of these precision-made ball bearings are helping America at peace. By increasing production—by cutting costs —by serving industry in every field.



Automatically following every change in course of enemy ship—the Bat hits the target. First such weapon successfully used in combat by any nation.

*(*Sponsored by U. S. Navy Bureau of Ordnance and Bureau of Standards, the Bat is 12 feet long, has a 10-foot wing span. Official U. S. Navy photographs.)*

nothing rolls like a ball

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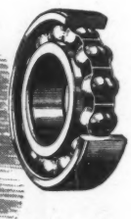
forged steel
BALL BEARINGS



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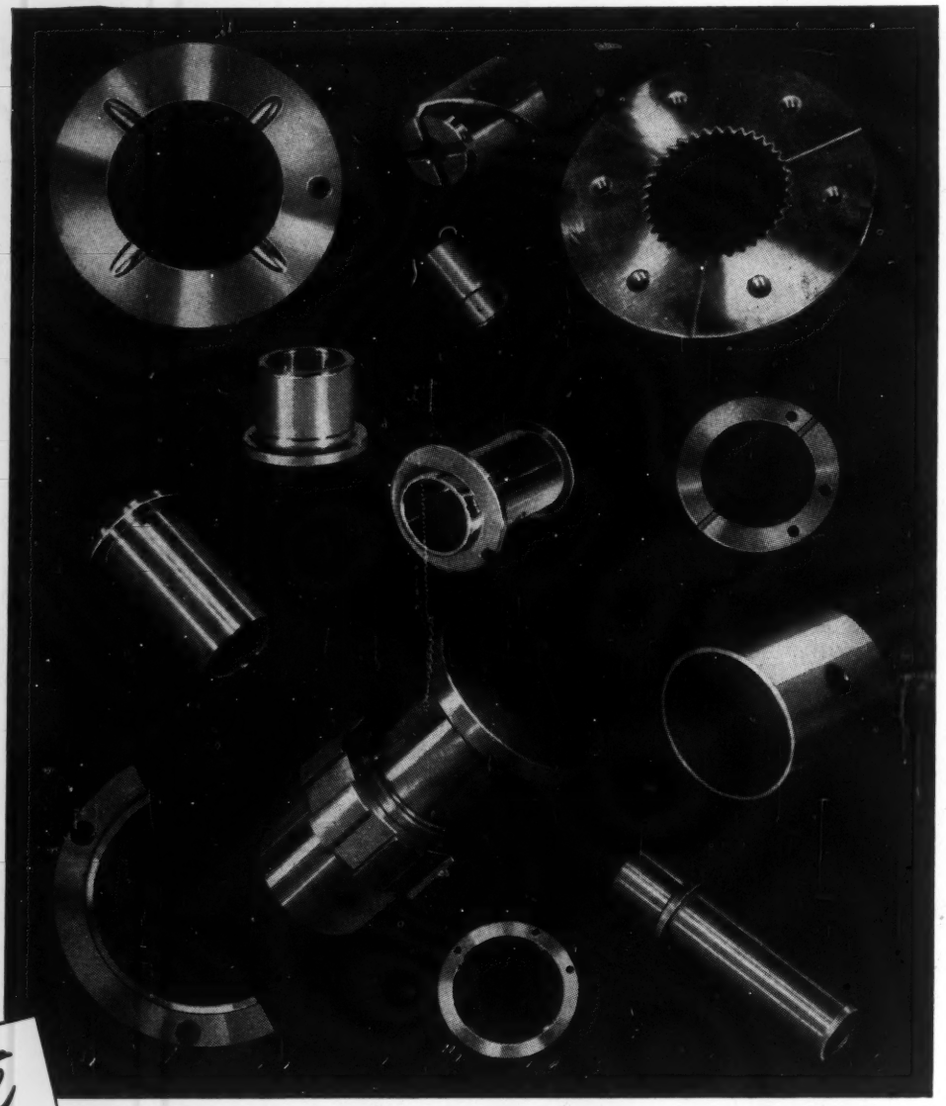

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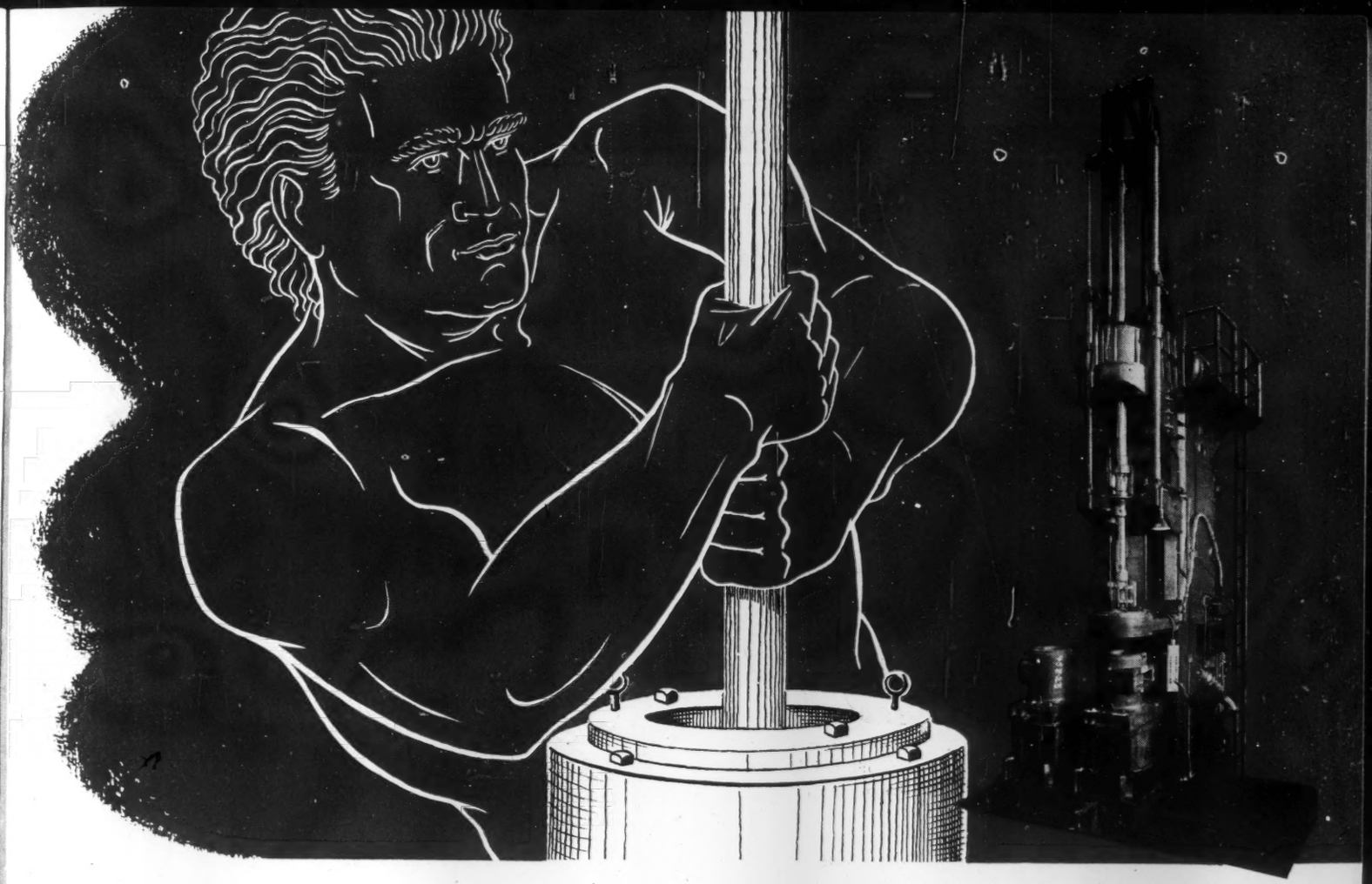


Giant Diesel Cylinder Hone employs Oilgear Fluid Power

Gains shock-free, rapid reciprocation, improved product

Like all progressive manufacturers, Cooper-Bessemer is always trying to produce better and better machines. To produce better *diesels,* Cooper-Bessemer built for themselves a hone capable of polishing diesel cylinders six feet long with a 26-inch bore. It turned out to be the world's biggest . . . 20 feet high.

As with other outstanding machine builders, Cooper-Bessemer came to Oilgear for the equipment to make this giant hone work with the required accuracy, quality and speed. An Oilgear pump supplies controlled power to two 3⅞" x 90" cylinders that smoothly, shocklessly reciprocate the great hone. Adjustable thermostatic chokes in the Oilgear combination valves provide high speed, cushioned, controlled reversal of the hone. Another Oilgear cylinder 3" x 50" moves the work table from loading position to honing position and back again. Remote control from a portable panel enables the operator to select the reciprocating speed from the work station.

Foremost in fluid power, serving the nation's noted industrialists, Oilgear simplifies design, manufacture and operation, speeds production, cuts costs; Oilgear is competent to solve any problem of yours in the fluid power range. Ask for further information. THE OILGEAR COMPANY, 1305 W. Bruce Street, Milwaukee 4, Wisconsin.

Oilgear Fluid Power pump, cylinders and control system reciprocates the giant hone in the Cooper-Bessemer machine with a maximum rate of 680 inches a minute. Also moves work table from loading to honing position. Reversal is cushioned, controlled, shock-free. Operation is automatic at the touch of a button.

OILGEAR

ARE YOU TRYING TO:

1. Apply large forces through long . . . or short . . . strokes at variable speeds?
2. Obtain automatic work cycles, variable speeds in either direction . . . with or without preset time dwell?
3. Apply large forces through continuous or intermittent reciprocating cycles at constant or variable velocities?
4. Obtain extremely accurate control of either position or speed of a reciprocating member?
5. Apply accurately variable pressure either static or in motion?
6. Closely synchronize various motions, operations or functions?
7. Apply light . . . or heavy . . . forces at extremely high velocities through either long or short distances of travel?
8. Obtain continuous automatic reversing drives at constant R.P.M. or over a wide range of speed variation?
9. Obtain accurate remote control of speed and direction of rotation, rates of acceleration and/or deceleration?
10. Obtain constant horsepower output through all or part of a speed range?
11. Obtain automatic torque control?
12. Obtain accurately matched speed of various rotating elements?
13. Obtain constant speed output from a variable speed input?
14. Obtain full preset automatic control, elimination of problems of shock, vibration, etc.?

You Need Oilgear!

Oilgear Fluid Power

MAXITORQ FLOATING DISC MAXITORQ FLOATING DISC MAXITORQ FLOATING DISC MAXITORQ FLOATING DISC MAXITORQ FLOATING DISC MAXITORQ FLOATING DISC MAXITORQ FLOATING DISC MAXITORQ

If you need

AN AUTOMATIC OVERLOAD RELEASE CLUTCH

Let's talk

"MAXITORQ"

Single type Maxitorq Automatic Overload Release Clutch. Note disengaging cams.

If you are a Designer, Builder or User of High Speed Automatic machinery you will take every precaution to insure maximum safety to machine, operator and product . . . doubly so if the product is breakable or damageable.

"Let's talk MAXITORQ" is our invitation to you for a full explanation of the NEW MAXITORQ Overload Release Clutch that provides instant disconnect when the clutch is overloaded. By means of a simple finger-tip adjustment the clutch can be set to transmit the normal running load but it automatically disengages when overload occurs, and positively slips into neutral.

The Maxitorq may be assembled, adjusted, and taken down without the use of tools. The patented Separator Springs actually "float" the discs apart in neutral, preventing drag, abrasion . . . and consequently, heating.

Available in 6 standard sizes, ¼, ½, 1, 1¾, 3 and 5 H.P. at 100 R.P.M., for use on a continuous shaft or as a cut-off coupling type for connecting two shafts.

If you need instant release . . . this is your best buy . . . just as the Standard Maxitorq is when the release feature is unnecessary. Both types are engineered with our 40 years of clutch designing as a dependable background. Specify Maxitorq for the best of power transmission and control.

Send for new Catalog No. MD1

Standard Maxitorq . . used when automatic release is unnecessary.

TRADE MAXITORQ MARK

THE CARLYLE JOHNSON MACHINE COMPANY
MANCHESTER CONNECTICUT

LINK-BELT COMPANY
519 N. Holmes Ave., Indianapolis 6, Ind.

Please send me

☐ Roller Bearing Book No. 2095

☐ Ball Bearing Book No. 2094

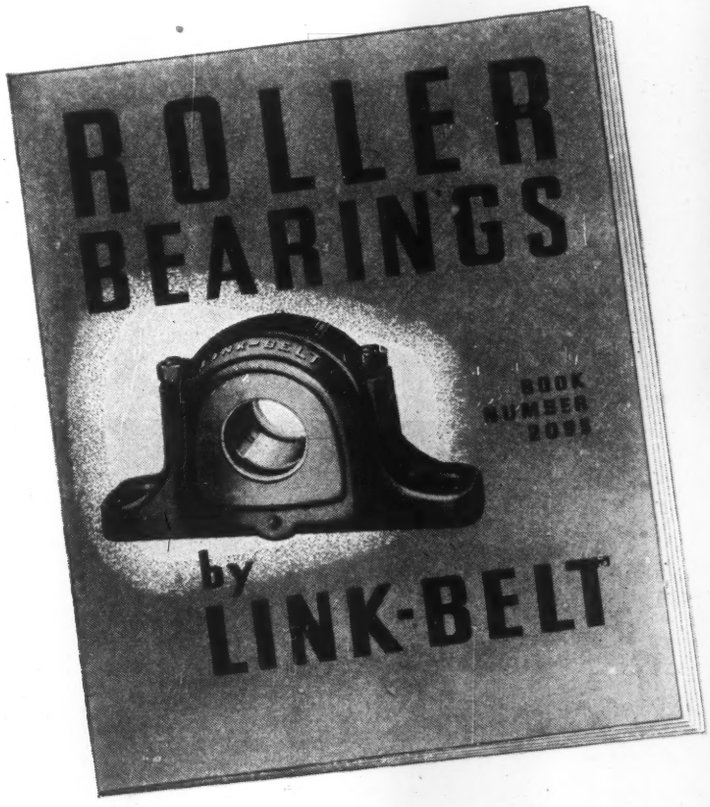
Name _____

Firm _____

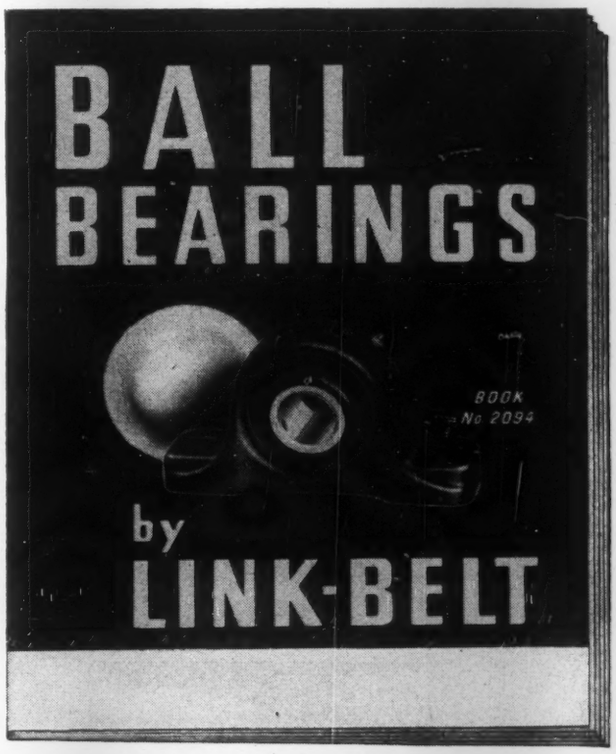
Address _____ *Zone* _____

City _____ *State* _____

. . . . these books will help you select the right ball or roller bearing. Ask for them.



Book No. 2095 describes Link-Belt's line of Roller Bearing Self-Aligning Pillow Blocks of the adapter and press-fit-on-shaft types. Book contains engineering selection data and capacity tables and dimensions.



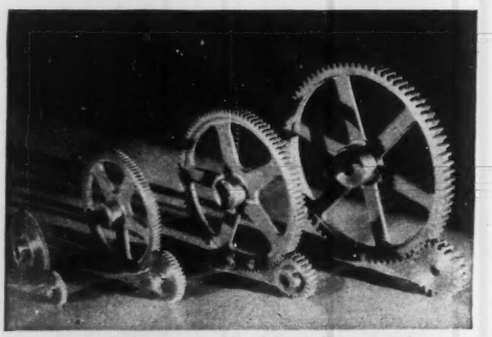
Book No. 2094 describes Link-Belt's line of Ball-Bearing Pillow Blocks, Flange Units, Cartridge Units, Hanger Units, Take-up Units, and Complete Take-ups. Contains engineering data, capacity and dimension tables.

Manufactured by
LINK-BELT COMPANY
Chicago 9, Indianapolis 6, Philadelphia 40, Atlanta, Dallas 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8.
Offices, Factory Branch Stores and Distributors in Principal Cities.

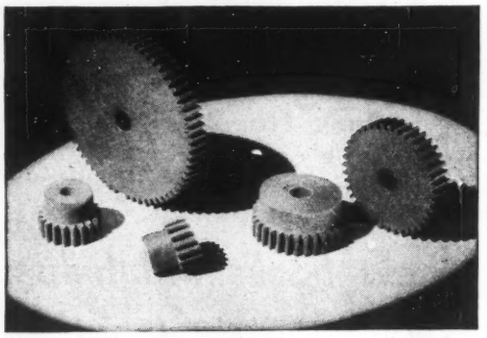
10,502

look to LINK-BELT for bearing service

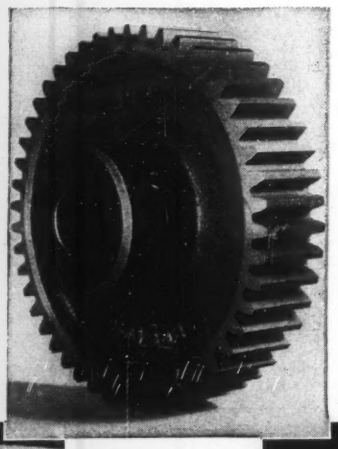
TO MAKE YOUR WHEELS TURN
USE BOSTON STANDARD SPUR GEARS

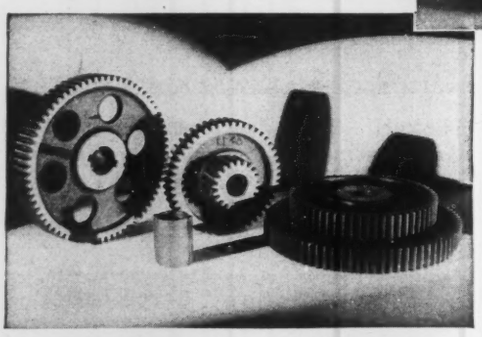


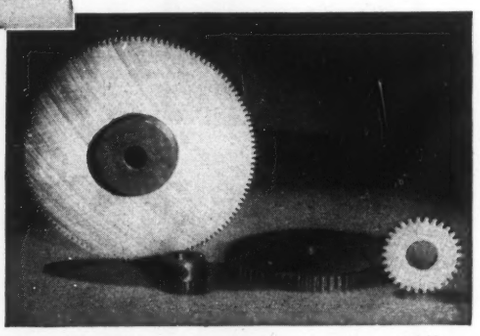
Brass spur gears in 48, 32, 24 and 16 pitch and in sizes from $\frac{5}{64}$" to 6" pitch diameter.



Non-metallic spur gears in diametral pitches from 16 to 3 and in sizes from $\frac{15}{16}$" to 6⅔" pitch diameter.







Iron and steel spur gears, 14½° pressure angle, in diametral pitches from 32 to 3 and in sizes from ½" to 40" pitch diameter; also 20° pressure angle in diametral pitches from 16 to 5 and in sizes from 1" to 36" pitch diameter.

BOSTON GEAR WORKS, INC.
NORTH QUINCY 71, MASS.

Branches: **Atlanta, Chicago, Cleveland, Los Angeles, New York, Philadelphia and Utica, N. Y.**

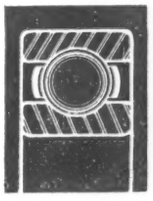
Distributors throughout U. S. A. and Canada

BEARING FACTS NO. 2

The Single Row Ball Bearing

ITS USE AND ADVANTAGES

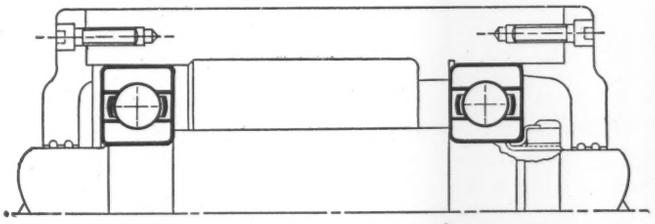
AS PRODUCED BY NORMA-HOFFMANN



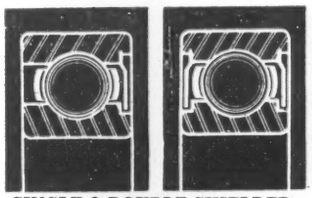
DEEP GROOVE NON-FILLING SLOT TYPE

This is the most widely used type of all anti-friction bearings. It can carry both radial and comparatively heavy thrust loads. Its uninterrupted, symmetrical raceways and self-contained, deep-groove design give it a wide range of application. Special types are available with ultra-precision tolerances. Here are some of its advantages:

- Self-contained. Can be handled and mounted as a complete unit.
- Has equal thrust capacity in either direction.
- Close conformity of raceway with ball contour provides maximum load support.
- No adjustment. Bearings delivered with required internal clearance.



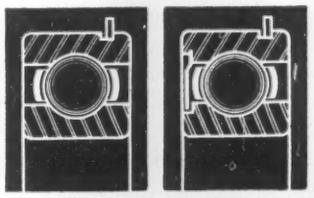
- In two-bearing applications (as above) one bearing can be locked in the housing, the other "floated." This allows for expansion due to temperature changes and compensates for variables in machining shaft and housing shoulders.



SINGLE & DOUBLE SHIELDED

The side plates are fixed in outer ring and extend into recess of inner ring forming labyrinth to retain grease, exclude dirt.

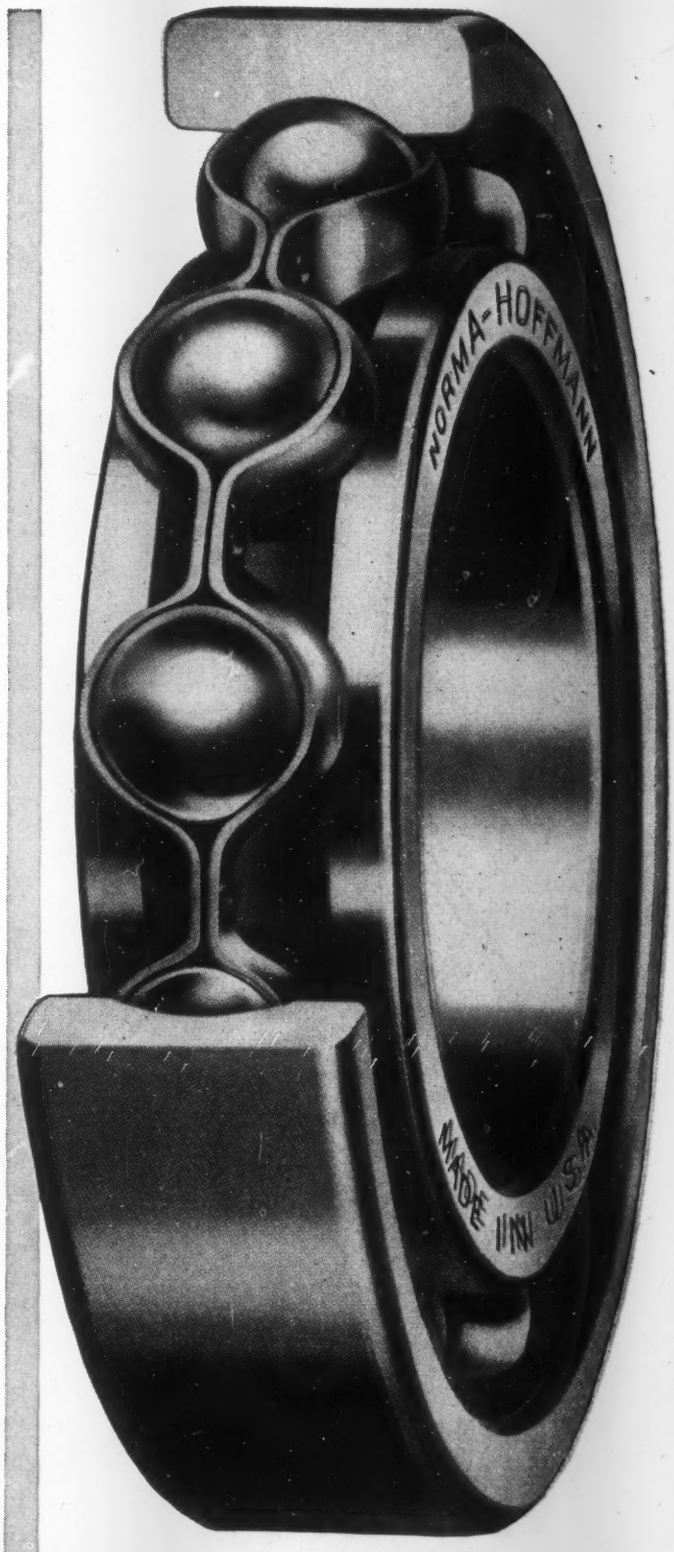
1. Provides economical closure for many ordinary uses.
2. Supplements other seals for extra dirty applications.
3. Occupies no greater space than standard single row bearing.
4. Pre-packed with Norma "Stability-Tested" Grease; long service without relubrication is assured.



SHOULDER (SNAP) RING TYPE

This bearing is equipped with a split metal locating ring which is snapped into a groove in the outer ring of the bearing.

1. Self-locating; no need for providing machined housing shoulders.
2. Permits simplest housing: a straight through bore.
3. Provides longitudinal compactness with saving of materials and weight.



"NORMA-HOFFMANN"

PRECISION BALL, ROLLER AND THRUST BEARINGS

NORMA-HOFFMANN BEARINGS CORPORATION
STAMFORD, CONNECTICUT
FIELD OFFICES: New York, Chicago, Cleveland, Detroit, Pittsburgh, Cincinnati, Los Angeles, San Francisco, Portland, Ore., Seattle, Phoenix

Plastics bring the precious gift of Space!

DESIGNERS! Here's space. Space where it counts most—extra space—in close quarters, awkward corners, conduits, congested assemblies. Space saved by the surprisingly *small-diameter*, thin-wall cross-section of wire covered with VINYLITE Brand Plastic or BAKELITE Brand Polyethylene insulation and jackets.

In machine tools, in machinery and electrical equipment of almost any type, built-in wiring protected with these plastic materials pays its way many fold. Their extreme flexibility makes installation easy, permits more compact designs. They are highly resistant to all the common menaces that electrical wiring must face—moisture, acids, oils, grease, most chemicals and abrasion. Their dielectric strength is phenomenal.

By nature, these plastics are non-aging. Some formulations are non-flammable, others slow-burning. Since their surface is smooth and sleek, they are virtually free from friction.

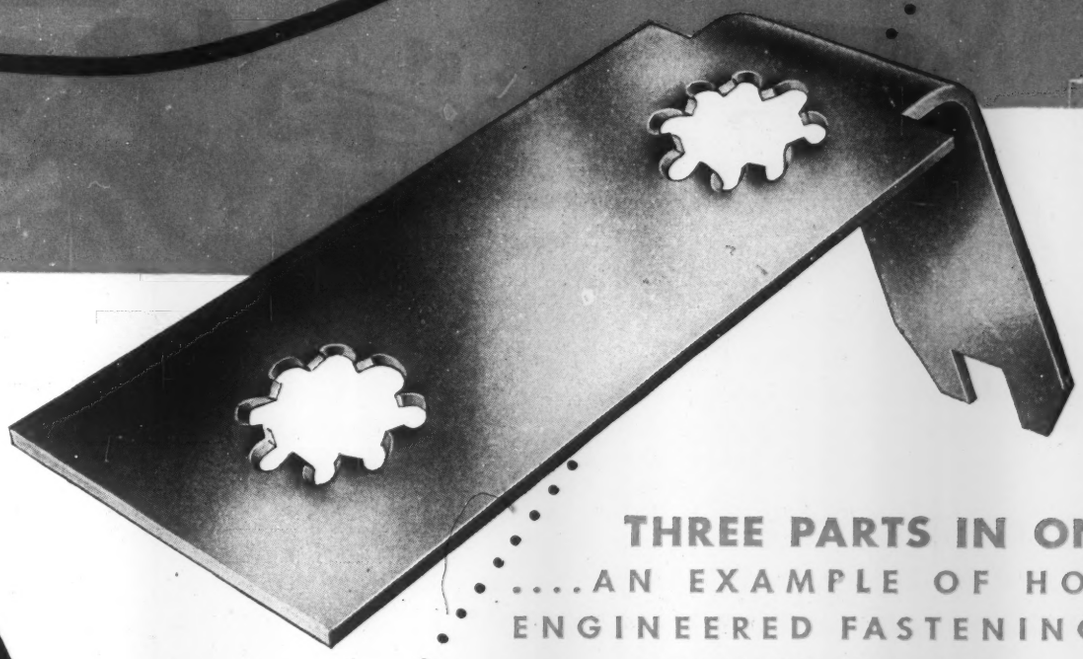
For easy identification, VINYLITE coverings are available in many colors. They may be opaque, transparent or crystal-clear.

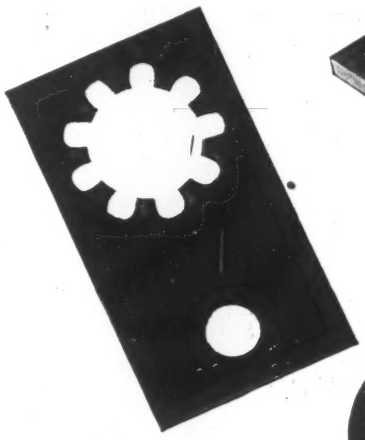
They combine all needed properties for reliable service. And above all . . . they bring the precious gift of *space*. Write Department BP-4 for detailed technical data on VINYLITE plastic and BAKELITE polyethylene insulation and jacketing. Prompt attention will be given inquiries requiring consultation of Bakelite engineers.

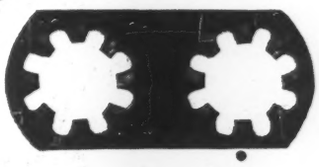
VINYLITE
TRADE—MARK
PLASTICS

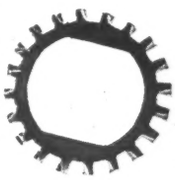
BAKELITE CORPORATION, *Unit of Union Carbide and Carbon Corporation* UCC 30 East 42nd Street, New York 17, N. Y.

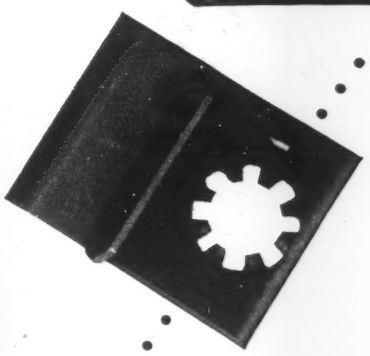
Here's a SHAKEPROOF Cost-Saver!

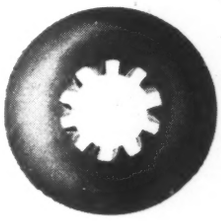










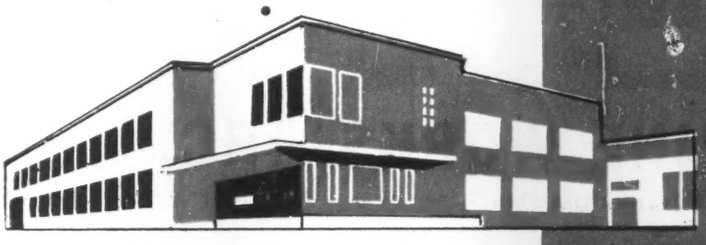


THREE PARTS IN ONE

....AN EXAMPLE OF HOW ENGINEERED FASTENINGS REDUCE COSTS!

Cost is a lot of little things. Here is one small part of an assembly that originally called for installation with two lock washers under screws. With production calling for thousands of these parts monthly, unit assembly time is important. In addition, the essential lock washer *might* be omitted by a hurried worker. But by calling Shakeproof Inc., the manufacturer obtained an *engineered part* which incorporated the locking feature so necessary . . . eliminated the use of separate lock washers . . . reduced his material cost . . . lowered assembly charges . . . increased the speed of attachment . . . and became absolutely sure of quality control.

If you are planning to use small stamped parts that must be locked tight, where high production and speed of assembly are important factors, it will pay you to investigate the advantages of Shakeproof Engineered Fastenings. Do it today!



SHAKEPROOF INC.

Fastening Headquarters

Division of ILLINOIS TOOL WORKS

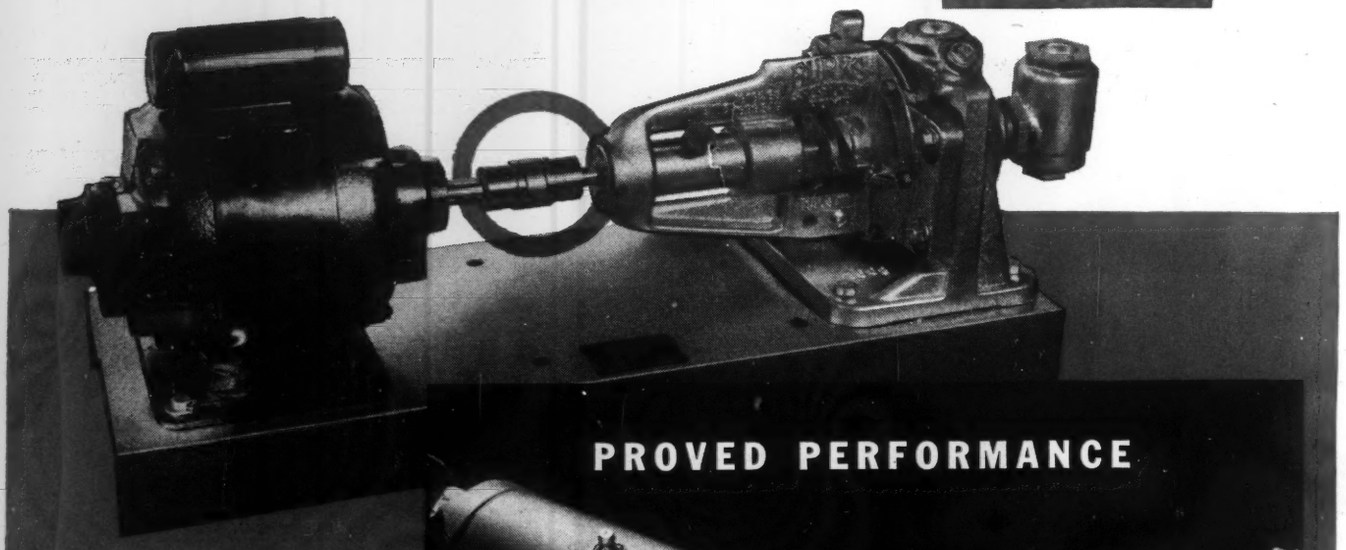
2501 North Keeler Avenue, Chicago 39, Illinois

633 South Lakeview Ave., Los Angeles 26, Cal. 2093 E. Grand Blvd., Detroit 2, Mich.

Plants at Chicago and Elgin, Illinois. In Canada: Canada Illinois Tools, Ltd., Toronto, Ontario

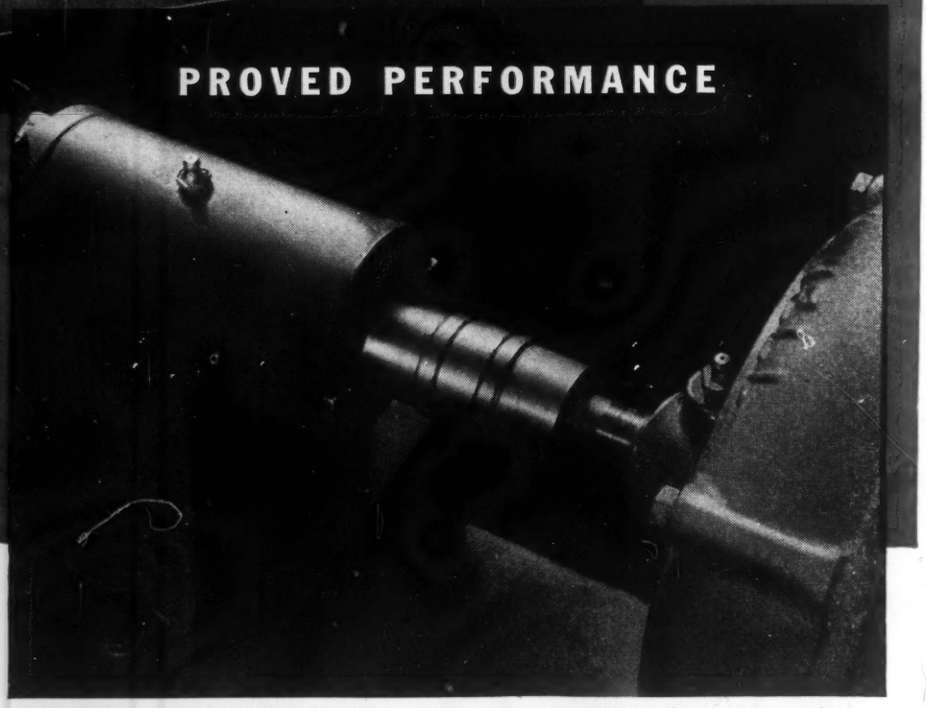
CUT COUPLING COSTS...

with the *New* IMW



A typical IMW application by the Aetna Engineering Co., Hanover, Mass., for a direct power transmission from a motor to a centrifugal pump. IMW coupling has made possible smooth, efficient operation with no backlash or excessive vibration. Misalignment has been automatically corrected.

PROVED PERFORMANCE



EASY TO INSTALL

QUIET OPERATION

The IMW coupling application shown above has proved to Cranberry Canners, Inc., South Hanson, Mass., the efficiency of this remarkable new coupling. Constant high-speed operation has established its durability. Cranberry Canners' engineers particularly like the IMW's simplicity of construction which makes assembly and inspection quick and easy. Its greater flexibiiity corrects angular and parallel misalignment simultaneously.

IMW GEAR-TOOTH COUPLING

INDUSTRIAL MACHINE WORKS, INC.

South Hanover, Massachusetts

DO A BETTER COUPLING JOB

GEAR-TOOTH *flexible* COUPLING

Corrects Angular and Parallel Misalignment
Wears Longer • Costs Less • DOES MORE . . . *quietly*

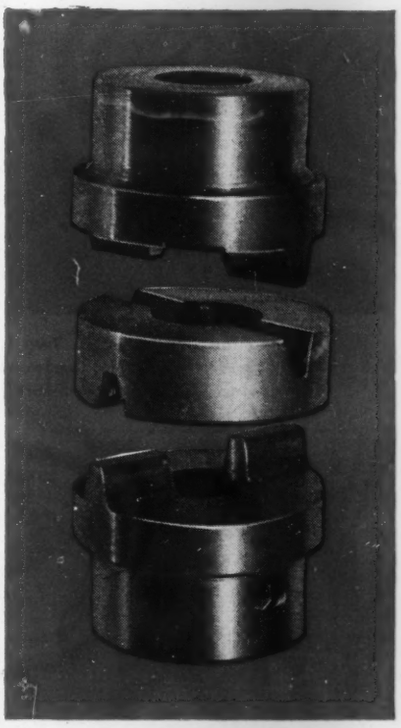
Simple 3-piece gear-tooth construction provides rocker action for more flexibility with minimum vibration and wear.

Plant performance has proved this 3-piece gear-tooth flexible coupling an important *new* development in coupling design. Two identical end-pieces with involute gear teeth mate with center-piece containing rack grooves running transversely on opposite sides. Each end-piece has two set screws — one on key and one 120° from key way.

- 2° angular correction either side of center — liberal parallel correction depending on size of coupling.
- Center-piece of lubricant impregnated sintered bronze (unless otherwise specified).
- High torque capacity suitable for high-speed application up to 1500 inch-pounds torque (in standard sizes).
- Gear-tooth design gives greater flexibility, longer life, quieter, more efficient operation.

Broad range of standard sizes up to 1¾ inch shaft diameter. Special sizes to specifications. Mail coupon below today for detailed data.

**Patent Pending*



NO BACKLASH

ALL METAL

LONG WEAR

HIGH TORQUE CAPACITY

SELF LUBRI-CATION

INCREASE YOUR COUPLING EFFICIENCY *NOW!*

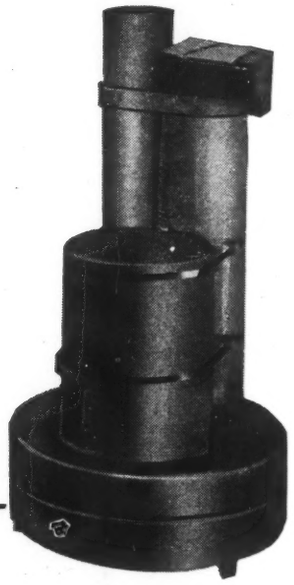
INDUSTRIAL MACHINE WORKS, INC.
10 Winter St., South Hanover, Massachusetts

Please send me your catalog giving additional detailed data on IMW Flexible Couplings.

Name .....

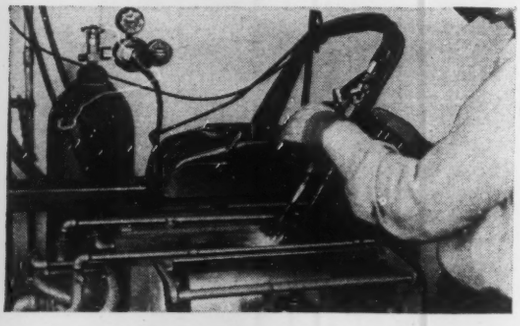
Business or Home Address .....

Lower Fabrication Costs with MECHANIZED OXY-ACETYLENE WELDING



Hot water heater fabricated by mechanized oxy-acetylene welding.

Welding the heater base. Two 15-in.-diameter flange-edged pieces are joined in less than a minute.



Welding the fuel tank of the heater. The 11 in. seam is welded in approximately one-half minute.

Welding a dished head to the fuel tank. The operation is completed in less than half a minute.

These pictures show some of the steps in the assembly of an immersion type hot water heater — just one of the many jobs that are "naturals" for mechanized oxy-acetylene welding. Initial equipment investment to do this work is low. Installation is simple and inexpensive. Maintenance costs are negligible. The smoothness of the welds produced by mechanized oxy-acetylene welding on this job completely eliminated the need for finish grinding. The speed of welding, 25 in. per min. on these 16-gage steel parts, provides for high production. Rejects are practically zero.

Use of mechanized oxy-acetylene welding helps to reduce costs, improve product quality, and increase production. Ask a Linde representative to show you how you can use this method in your shop.

THE LINDE AIR PRODUCTS COMPANY

Unit of Union Carbide and Carbon Corporation

30 E. 42nd St., New York 17, N. Y. UCC Offices in Other Principal Cities

In Canada: Dominion Oxygen Company, Limited, Toronto

Wichita City Libra

CASTINGS . . . *but they were "machined" in the mold!*

Now—all the advantages of Monel, Nickel and Inconel—available in PRECISION CASTINGS

HERE'S another way to lick tough design problems . . . *precision castings of Monel, Nickel and Inconel.*

The new INCO Precision Castings Plant is now in operation . . . built and equipped after years of pilot plant study, after thousands of experimental castings.

Check what this development means:

1 **Precision Castings of Precision Accuracy** — INCO precision castings are commonly made to tolerances of ± 0.003", and frequently to even finer tolerances.

2 **A Saving in Time and Money** — In general, INCO precision castings eliminate machining or other fabricating operations normally involved in making parts. This is particularly noteworthy where the design calls for intricate features and contours. Grinding away of the sprue and sand blasting are usually all that's required to make an INCO precision casting ready for assembly into the finished product.

3 **Broader Use for the INCO Nickel Alloys** — The flexibility of design permits the INCO Nickel Alloys to be used in shapes which frequently were neither economical nor practical to obtain as sand castings or by machining from forged stock or deep forgings.

4 **Dependable Source of Supply** — INCO handles precision castings as a mass production process . . . you can count on quick, steady production from INCO.

•

Perhaps an INCO Nickel Alloy precision casting is your answer to the need for faster production...for hardness, greater protection against stress, corrosion, high temperatures, wear and fatigue.

Let's go over your job together. Just send us a blueprint (or an actual sample). We'll be glad to work out all the information you want.

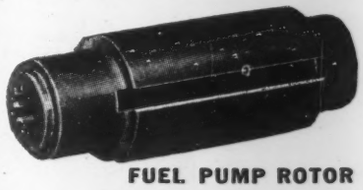
THE INTERNATIONAL NICKEL COMPANY, INC., 67 Wall Street, New York 5, N. Y.

NICKEL (INCO TRADE MARK) **ALLOYS**

MONEL* • "K" MONEL* • "H" MONEL* • "R" MONEL* • "S" MONEL* • INCONEL* • NICKEL • "L" NICKEL* • "Z" NICKEL*

*Reg. U. S. Pat. Off.

INCO PRECISION CASTINGS SAVE TIME AND MONEY



FUEL PUMP ROTOR

Formerly required 3 or 4 operations on 3 to 5 different machines. Note grooves on internal surface.

CLUTCH GEAR

Saved complicated machining. Also avoided at least one sub-assembly, i.e., force-fitting, welding or brazing the projecting key on small end.

FLIGHT CONTROL INSTRUMENT COVER

(*Cutaway section*) Originally machined from bar stock, taking a 9-day production schedule. Note intricate recesses and studs in recesses.

Above parts are made of "S" Monel

Time-saver on Piping "Specs" . . . the Complete CRANE Line

Watch how much faster you can specify from the Crane line. It puts everything at your finger tips—valves, fittings, pipe, accessories, and fabricated piping. For any design, you can choose without compromise, in brass, iron and steel materials.

Equipping with Crane means simplified buying and stocking of piping goods. Crane supplies everytning. Single responsibility for your needs assures smoother assembly operations; gives better control of factory schedules.

To machinery buyers in every field, Crane equipment signifies added value. They know that back of Crane Quality, there's 90 years' leadership in fine piping materials.

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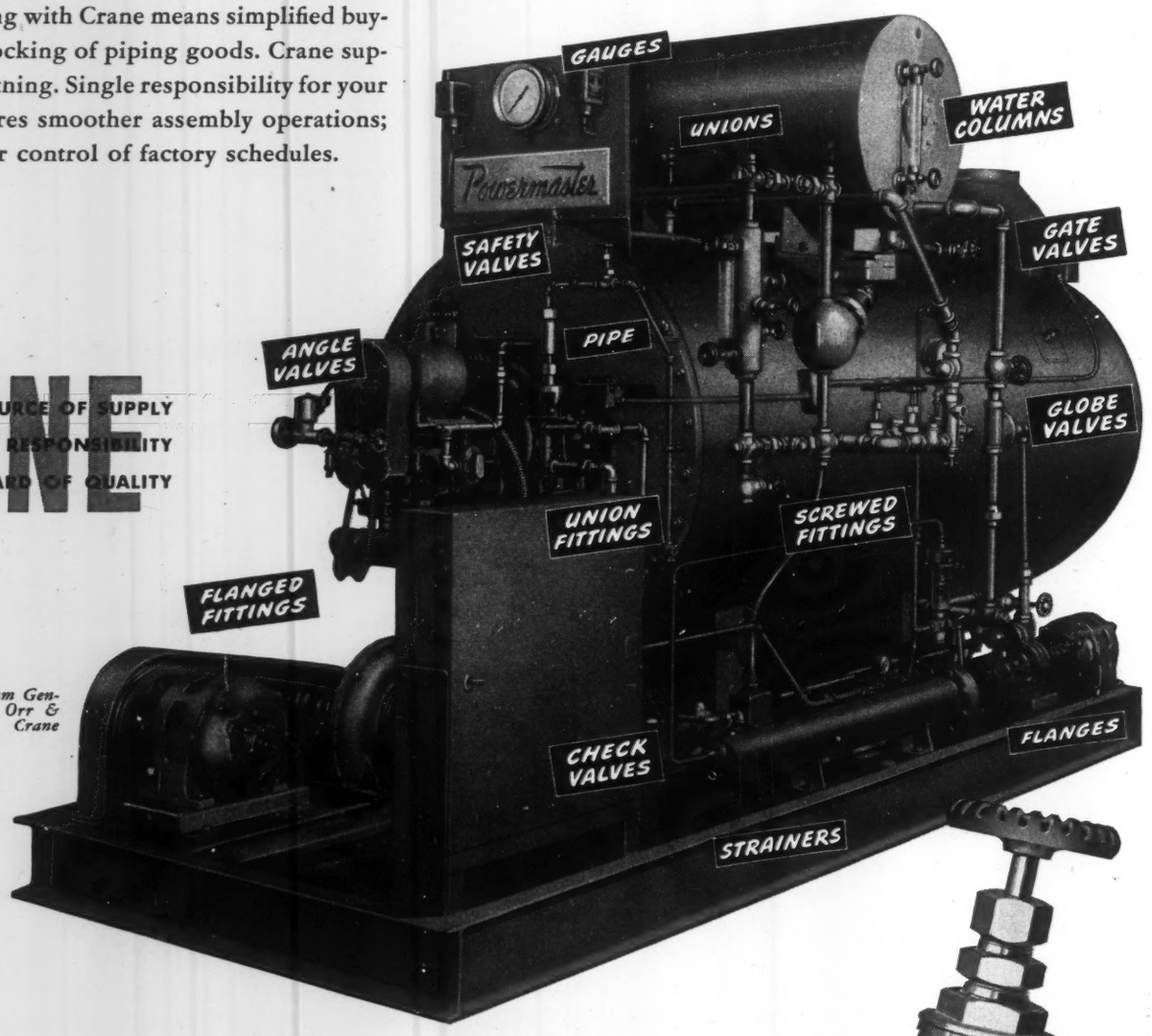

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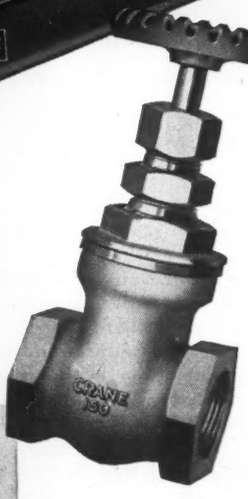

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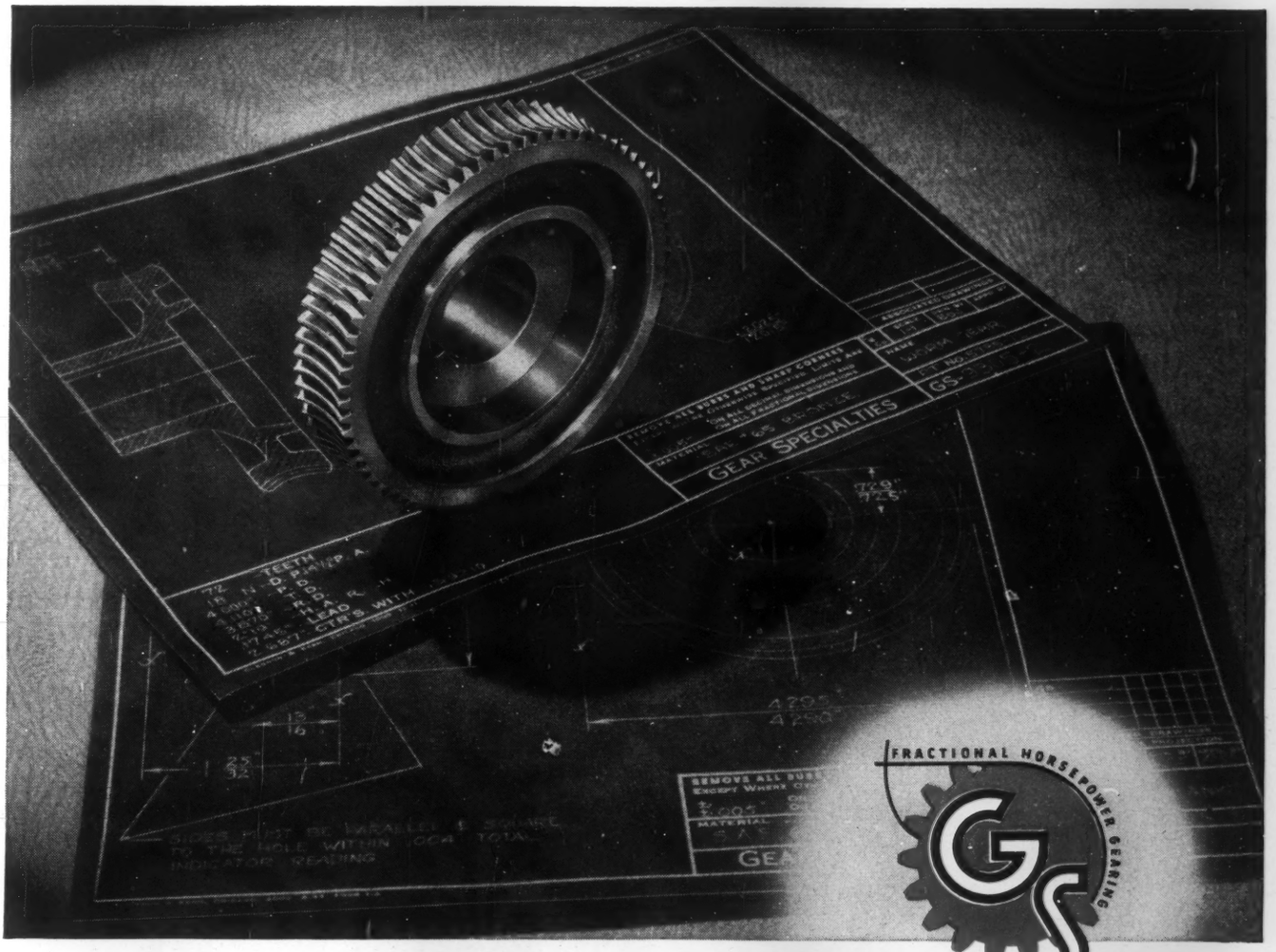

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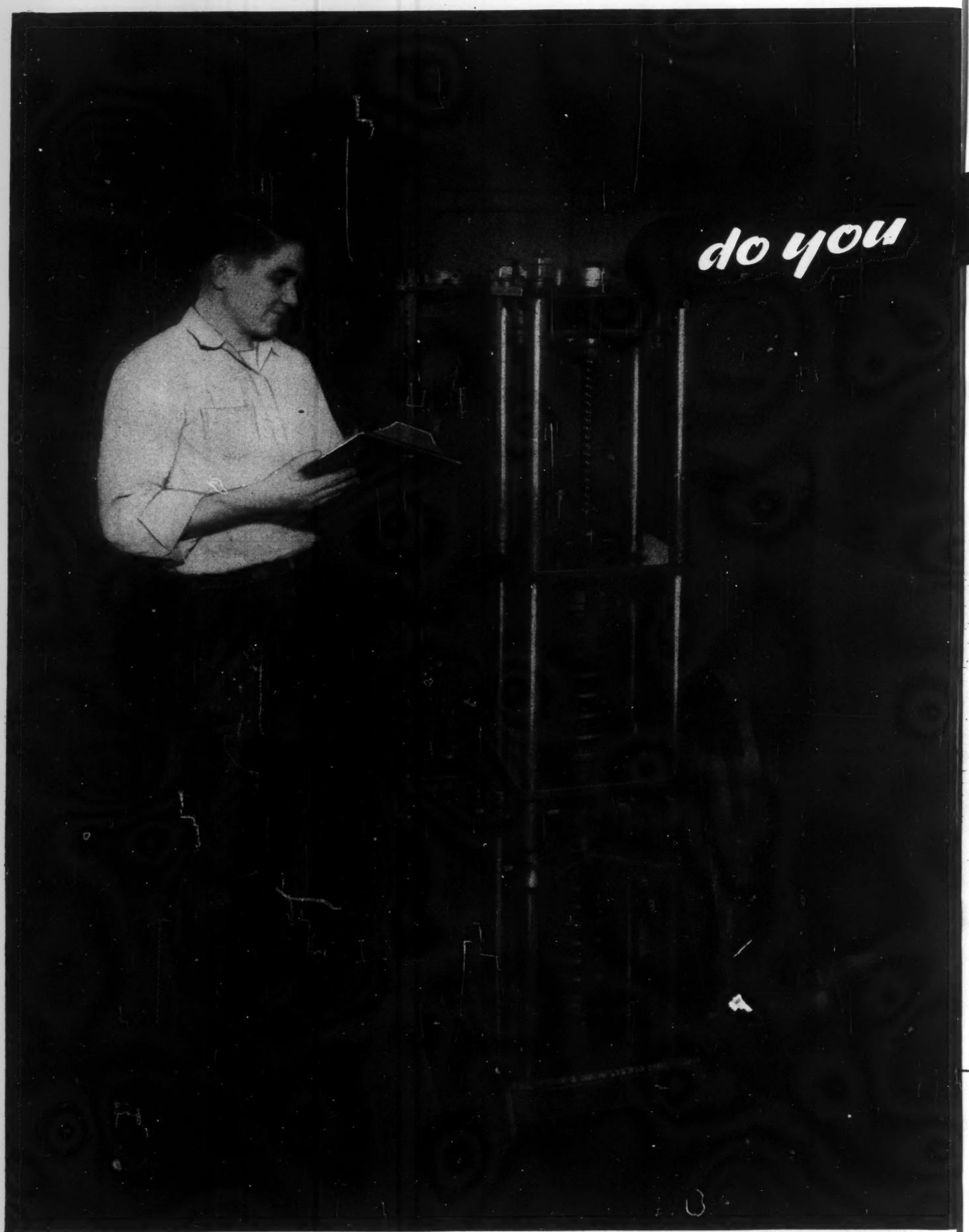
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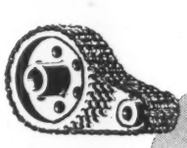

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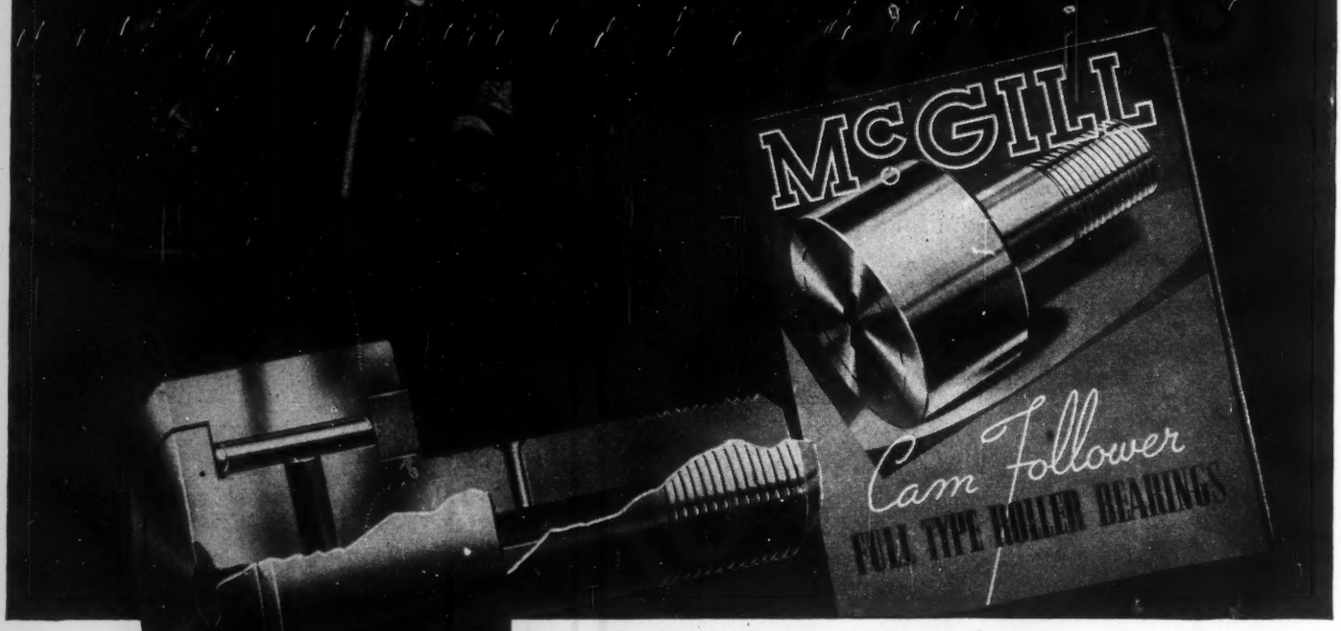

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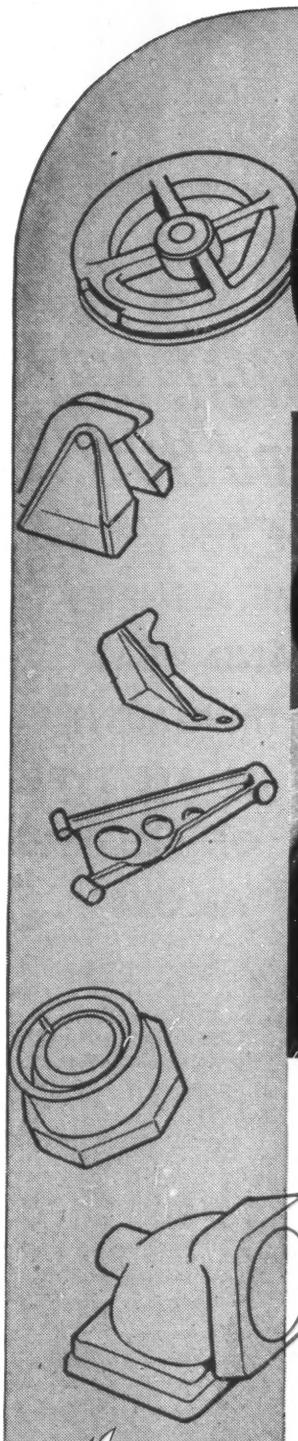

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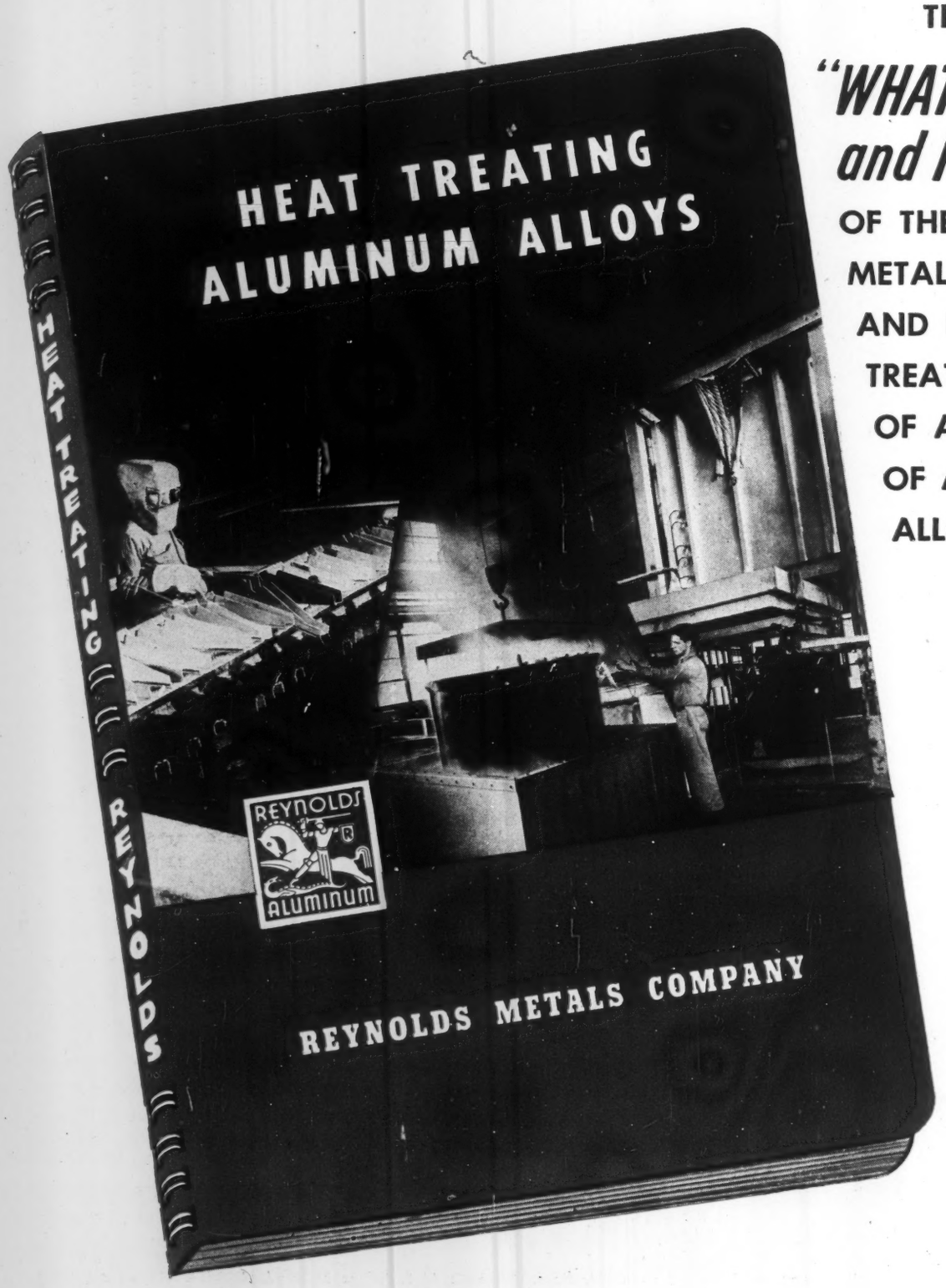

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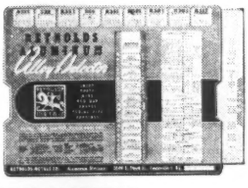

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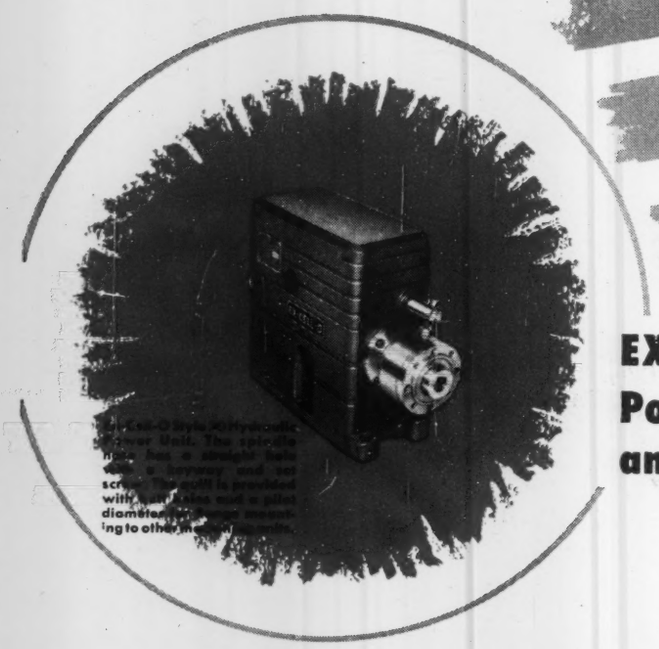

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Ex-Cell-O's Style 20 Hydraulic Power Unit is designed for the high spindle speeds required for operating small diameter tools efficiently. It is built to stand up under continuous, fast operating cycles. The automatic cycle includes rapid approach, two infinitely variable dial adjustable feed rates, and rapid return and stop. The unit is arranged for electric start and emergency return control.

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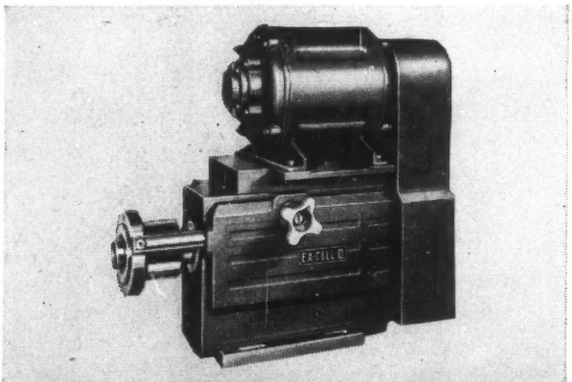
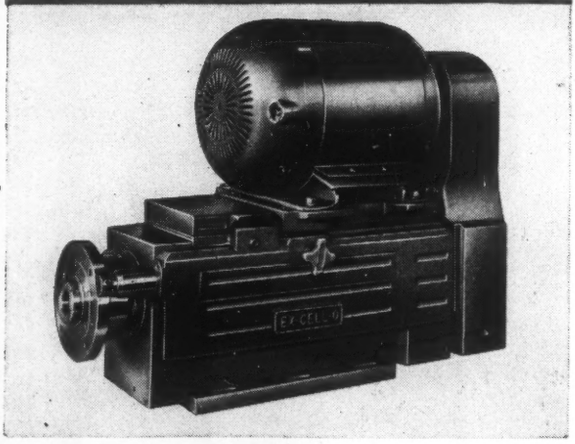
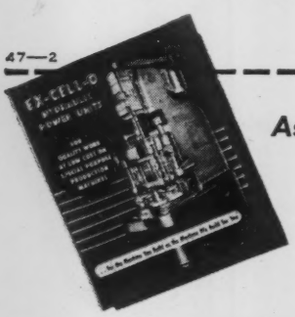


TWO OTHER SIZES—MEDIUM AND LARGE

Ex-Cell-O makes two other size hydraulic power units—(above) Style 21 (over-all length, without guard, 22¼") and (below) Style 28-A (over-all length, without guard, 38¼"). They are compact and self-contained for ease in installation. They have infinite feeds for proper cutting and provide ample power for multiple-head operation. Contact your local Ex-Cell-O representative today to see how Ex-Cell-O Power Units fit into *your* production program.



47—2



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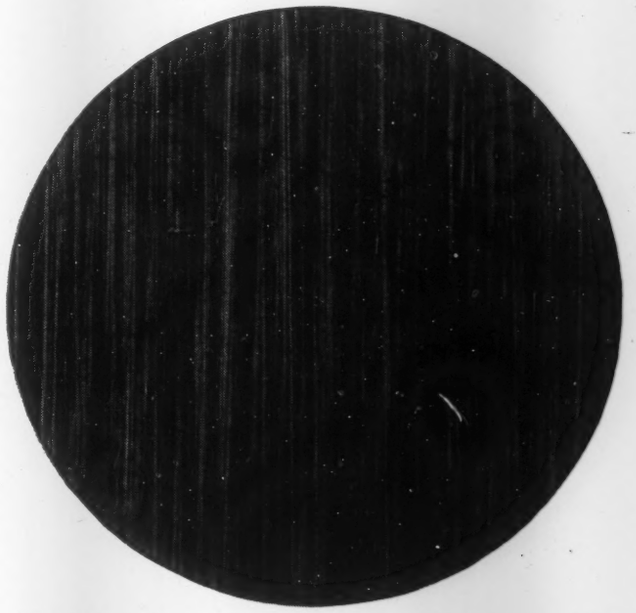

This photomicrograph (25 x magnification) shows a ground surface with the familiar scratches and ridges caused by single direction stock removal. Surface roughness is 35 micro-inches (Profilometer reading).

The same piece, 30% Superfinished to 15 micro-inches. Note how ridges have been reduced. A completely Superfinished surface of 2 to 3 micro-inches will leave no defects to penetrate the oil film or abrade the mating surfaces.

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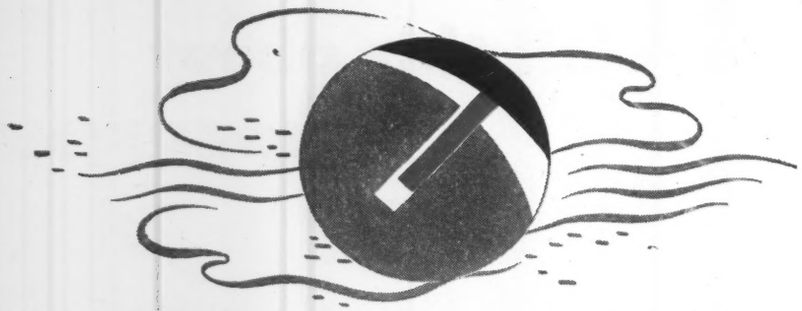

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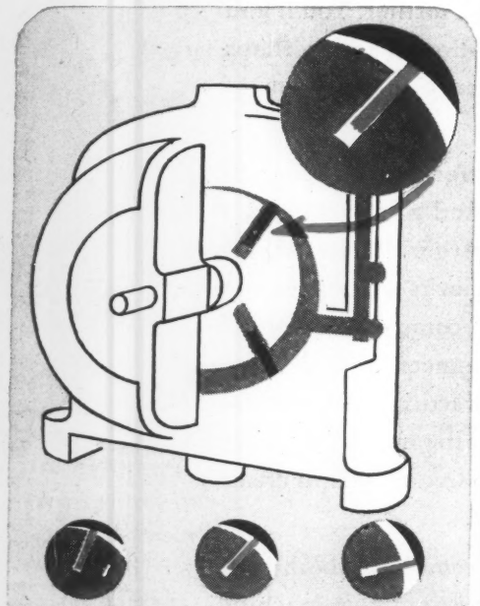

Vanes: Self-seating . . self-adjusting . . springless. Centrifugal force holds them against cylinder wall. They "work without works". . . Continuous, non-pulsating flow. . . More air per pound of weight, more air per horsepower. . . Forced-air cooling: long life, oil economy, no hot-oil odor . . . Automatic shaft seal: no packing, no leaking, no adjusting.

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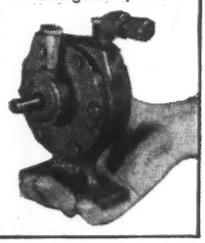

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It not only tells how Gasts are built and all about them, but suggests uses that may not have occured to you. Write for it; no charge or obligation!

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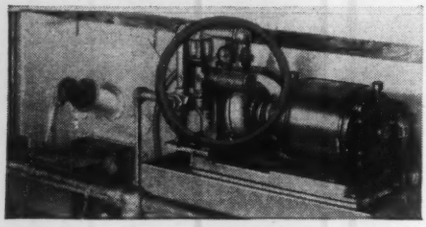
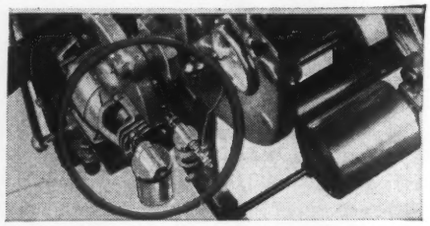


Supplying Air to Industrial Oil Burner



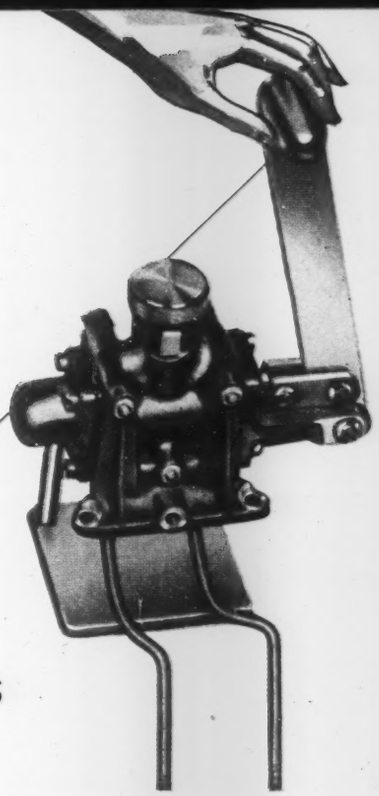
Vacuum Service on a Labeling Machine

1413

DESIGNED FOR MARINE USE, THIS

Hydraulic Remote Control

is built with *Rustless* Anaconda Metals



The principle of hydraulic remote control is not new. Its efficiency and simplicity have been amply demonstrated in large military aircraft.

Applying this principle to marine applications, the Marine Equipment Division of Ellinwood Industries in Los Angeles has developed a compact, automatically compensated, positive remote control unit that will transmit 500 inch-pounds of torque through an angular displacement of 60 degrees, with the "master" control and operating "slave" as much as 150 feet apart—both coordinated to a thousandth of an inch! Thus, a simple solution is offered for the problem of remote regulation of throttles, clutches, governors, valves and similar primary controls.

Now, take a look at the components of the dual master control unit illustrated on the following page. Each part is made of a strong, tough, durable copper alloy and, with the exception of the red brass castings, all are Anaconda Metals. Copper, yellow brass, free-cutting brass, phosphor bronze and Tobin Bronze*. *Each* contributes its special physical properties to a specific purpose . . . *all* are rustless, corrosion-resistant, sea-going metals, products of The American Brass Company—for years, Industry's principal supplier of copper and copper base alloys.

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THE AMERICAN BRASS COMPANY

General Offices: Waterbury 88, Connecticut

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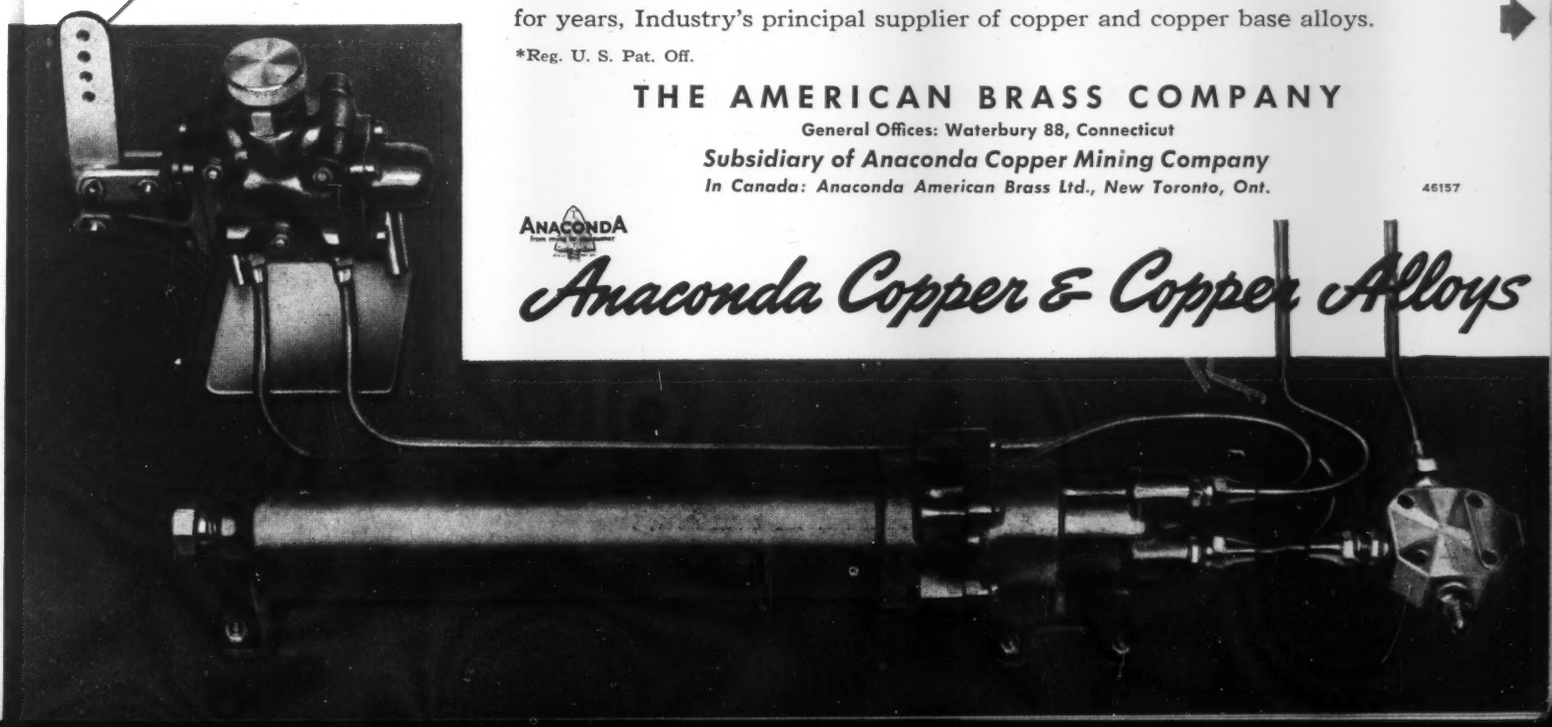
ANACONDA

Anaconda Copper & Copper Alloys



ANACONDA
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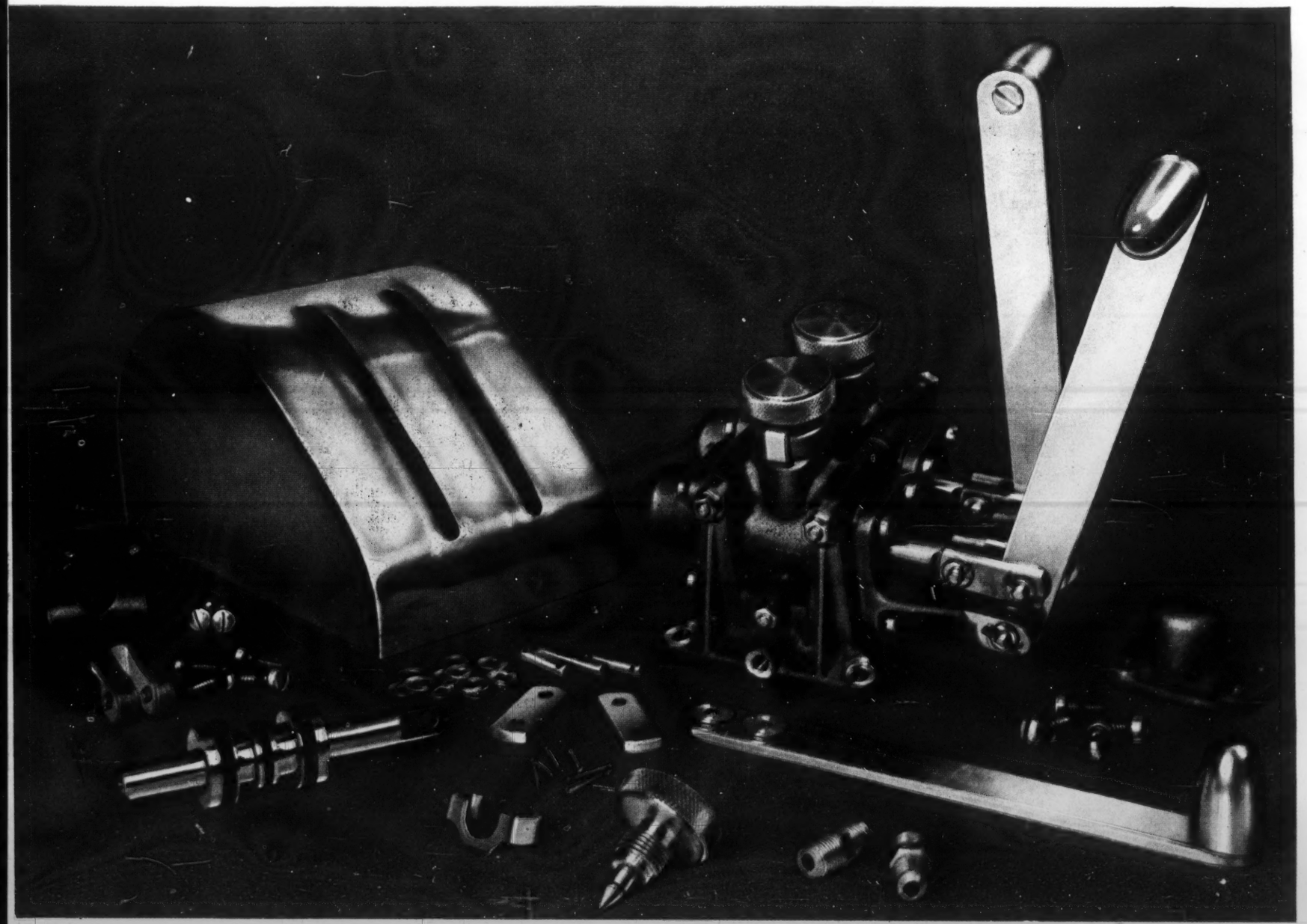
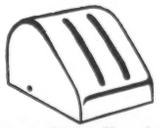
ANACONDA COPPER ALLOYS

extensively used in constructing the *Ellinwood* Marine Control





Sheet Brass Housing, chromium plated

Brass Screws, Washers and Cotter Pins

Tobin Bronze* Shaft and Piston, chromium plated

Phosphor Bronze Tension Spring

Free Cutting Brass Screw Machine Parts

Tobin Bronze Lever and Turned Brass Handle, chromium plated

Tobin Bronze Needle Valve

Tobin Bronze Pins and Links, chromium plated

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General Offices:
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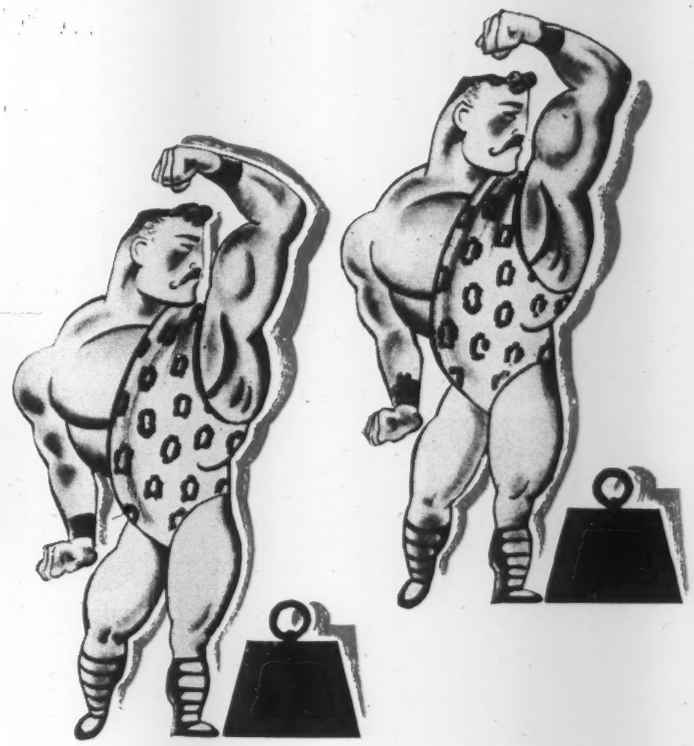
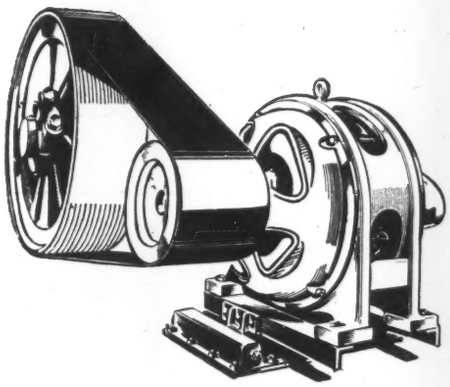
A PERFECT PAIR

for carrying big loads





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IT'S FLAT LEATHER BELTING

AND A PIVOTED MOTOR BASE

For heavy-duty jobs . . . for shock loads . . . for long, continuous operation . . . practical men pick this modern high-production drive. Flat leather belting has natural strength and gripping capacity. A pivoted motor base automatically maintains correct belt tension. When these two are combined, you get a drive that gives peak performance on the big loads and a higher percentage of time on the job.

AMERICAN LEATHER BELTING ASSOCIATION · 41 PARK ROW · NEW YORK 7, N. Y.

★ EXCELLENT ★

AGE RESISTANCE

RESILIENT parts made from HYCAR American rubber resist the aging effects of air, sunlight, ozone, heat, cold, and all other types of oxidation. That's why they *stay* resilient—and stay on the job for a long, long time.

Other important properties of HYCAR American rubber are shown in the box at the right. And it's important to know that these properties may be had in an almost limitless number of combinations—each compounded to meet a given set of service conditions.

We make no finished products of HYCAR. But we urge you to ask your supplier for parts made from this versatile material. You'll learn for yourself that it's wise to use HYCAR—in difficult or routine applications—for long-time, dependable performance. For more information, please write Dept. HN-1, B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio.

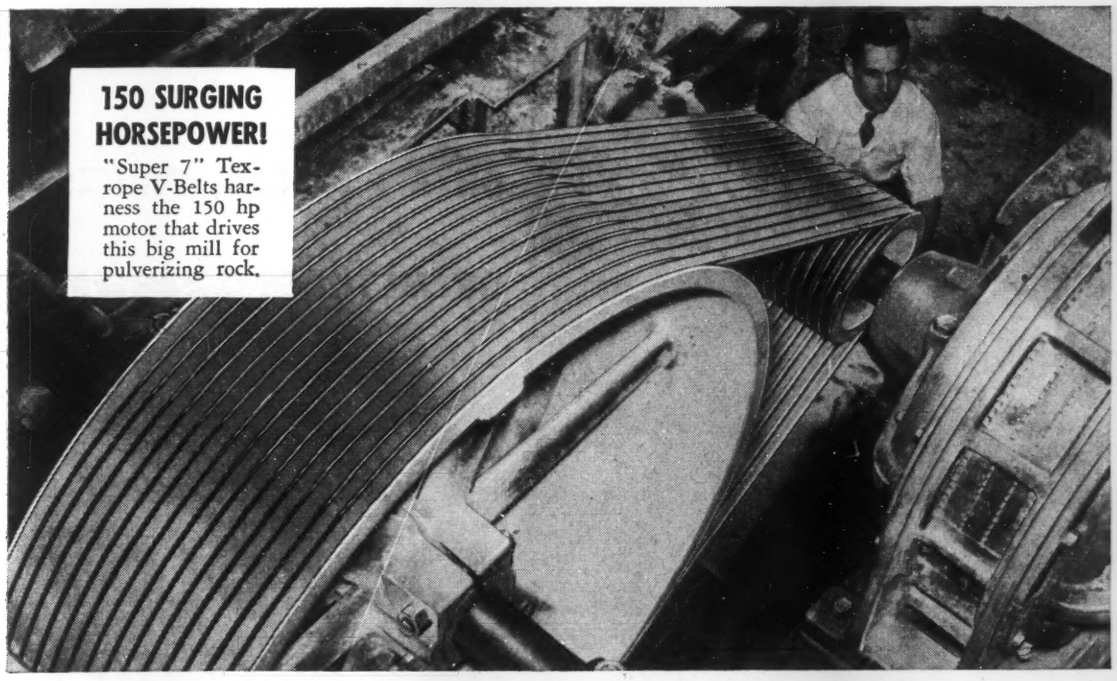
CHECK THESE SUPERIOR FEATURES OF HYCAR

1. *EXTREME OIL RESISTANCE — insuring dimensional stability of parts.*
2. *HIGH TEMPERATURE RESISTANCE—up to 250° F. dry heat; up to 300° F. hot oil.*
3. *ABRASION RESISTANCE—50% greater than natural rubber.*
4. *MINIMUM COLD FLOW—even at elevated temperatures.*
5. *LOW TEMPERATURE FLEXIBILITY — down to —65° F.*
6. *LIGHT WEIGHT—15% to 25% lighter than many other synthetic rubbers.*
7. *AGE RESISTANCE—exceptionally resistant to checking or cracking from oxidation.*
8. *HARDNESS RANGE—compounds can be varied from extremely soft to bone hard.*
9. *NON-ADHERENT TO METAL—compounds will not adhere to metals even after prolonged contact under pressure. (Metal adhesions can be readily obtained when desired.)*

Hycar
Reg. U. S. Pat. Off.
American Rubber

B. F. Goodrich Chemical Company
A DIVISION OF THE B. F. GOODRICH COMPANY

GEON polyvinyl materials • HYCAR American rubber • KRISTON thermosetting resins • GOOD-RITE brand chemicals

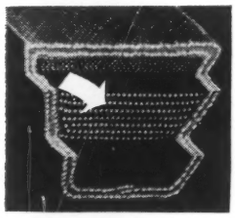


150 SURGING HORSEPOWER!

"Super 7" Texrope V-Belts harness the 150 hp motor that drives this big mill for pulverizing rock.

PULLING POWER

. . . one of the 7 Great Features in "Super 7" Texrope V-Belts!



1. **STRONGER CORDS** give "Super 7" Texrope V-Belts their great pulling power. These long-fibre, hard-twisted cotton cords have the strength of high-test fish lines. Laid row on row and imbedded in heat resistant rubber compound, they provide a powerful load-carrying element.

2. **TOUGHER COVER.** Rugged duplex construction protects the carcass of "Super 7" belts from wear and dirt.

3. **HEAT RESISTANCE.** *All* "Super 7" V-Belts are designed and built to give high resistance to heat.

4. **SHOCK ABSORBING.** "Super 7" construction combines great strength with the degree of resiliency necessary for long belt life and smooth power transmission.

5. **PRECISION CURED** in pressure molds to assure accurate section and perfect bonding of cords, cover and cushion.

6. **ACCURATELY MATCHED.** Every belt weighed, measured and carefully inspected before being sized and packed.

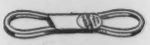
7. **ENGINEERING LEADERSHIP.** "Super 7" Texrope V-Belts represent 27 years of research and experience — by Allis-Chalmers, originator of the Multiple V-Belt Drive.

• • •

There are FIVE types of "Super 7" Texrope V-Belts, to meet every operating requirement: *Standard — Heat Resisting — Oil Resisting — Oil Proof* — and *Static Resisting.* Call your Allis-Chalmers office or dealer. ALLIS-CHALMERS, MILWAUKEE 1, WIS.

A 2161

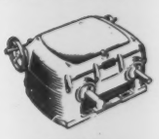
TEXROPE .. Greatest Name in V-Belt Drives



"Super 7" V-BELTS
Five Types — Sizes to suit every power transmission job.

Texsteel, Texdrive, "Magic-Grip"
— sheaves in a full range of sizes, grooves.

"Vari-Pitch" SHEAVES
Exact variations in speed, stationery or motion control.



SPEED CHANGERS
Speed variations up to 375% at the turn of a crank.

ENGINEERING
Finest V-Belt engineering talent in the world—at your call.

TEXROPE "Super 7" V-Belts result from the cooperative research of two great companies — Allis-Chalmers and B. F. Goodrich. They are sold only by A-C.

ALLIS-CHALMERS

One of the Big 3 in Electric Power Equipment — Biggest of All in Range of Industrial Products

1847 1947
A CENTURY OF SERVICE
to Industry
THAT MADE
America Great

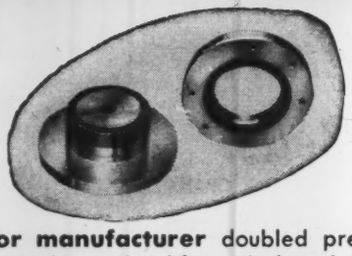
In the Dark...

ON A PRODUCT, PROCESS OR METHODS PROBLEM?

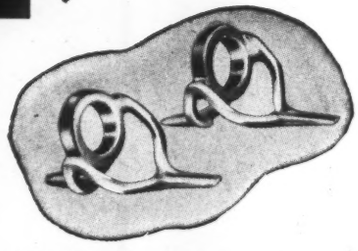
Then consider

CARBOLOY (TRADEMARK) CEMENTED CARBIDE

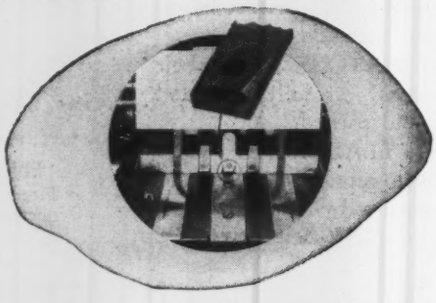
HARD METAL



A motor manufacturer doubled press speeds and stepped up die life with long-lasting Carboloy* punches and dies on silicon rotor steel.



A fishing-rod manufacturer increased useful life of rods many times by making line guides of wear-resistant Carboloy*.



A tabulating-machine manufacturer overcame abrasive wear of moving paper by making "throat block" part of Carboloy* (boosted trouble-free life from 30 days to over 6 months).

Secret of Carboloy Hard Metal's ability to solve *unusual problems* is these 6 *unusual properties* combined in ONE metal:

High Red Hardness—Extreme Density—High Abrasion Resistance—High Modulus of Elasticity—High Compressive Strength—Low Coefficient of Expansion and Contraction.

In these properties may be the answer to *your* problem. Why not write us today, describing it. We will analyze it, and make you a report, without obligation.

CARBOLOY* (TRADEMARK) CEMENTED CARBIDE

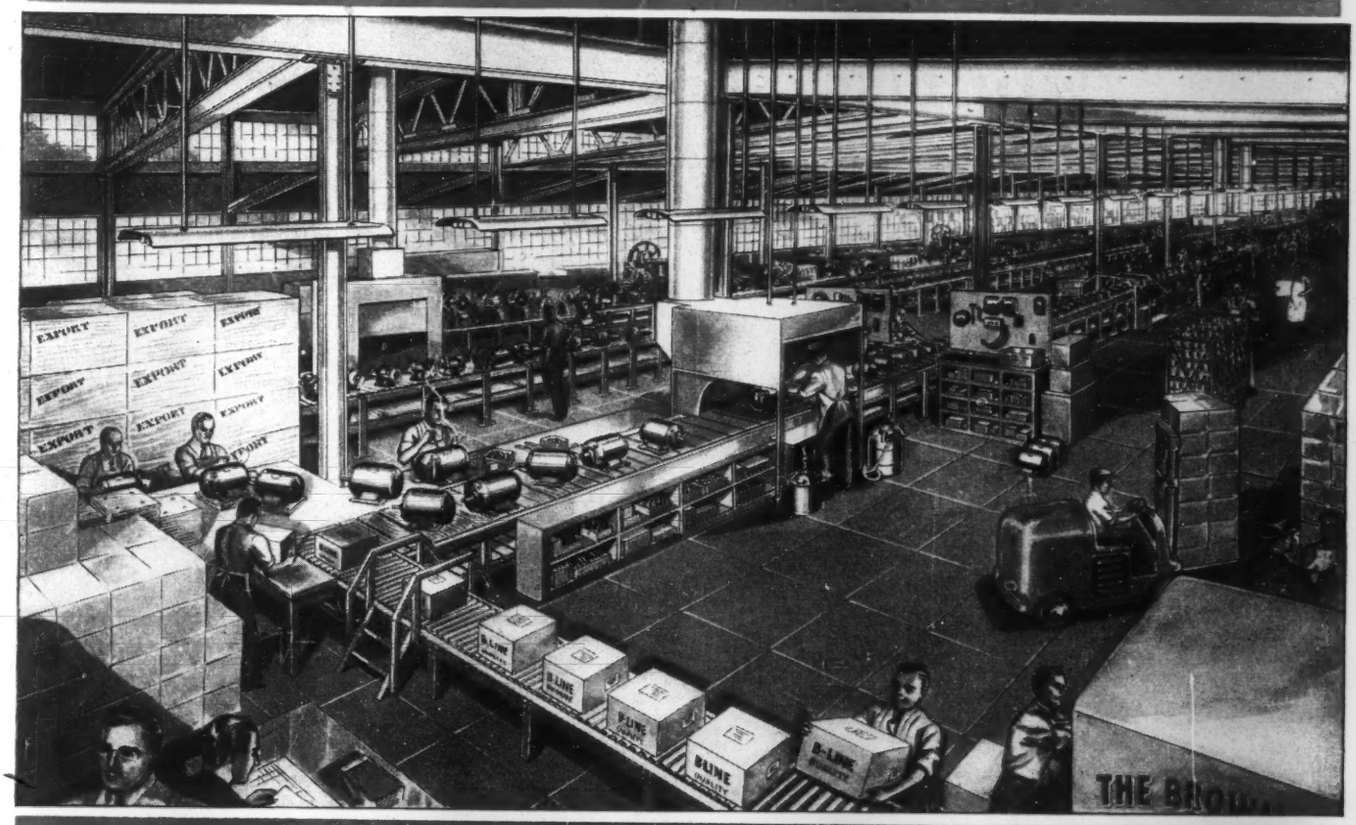
HARD METAL

ITS UNUSUAL PROPERTIES SOLVE UNUSUAL PROBLEMS

CARBOLOY COMPANY, INC.
11195 E. 8 Mile Blvd. Detroit 32, Mich.

CHICAGO • CLEVELAND • DETROIT • HOUSTON
LOS ANGELES • MILWAUKEE • NEWARK
PHILADELPHIA • PITTSBURGH • THOMASTON (CONN.)

B-LINE electric motors



More B-LINE Motors were manufactured in 1946 than during the first nine years we were in Production.

B-LINE prestige–"the result of 26 years of dependable performance".

WRITE FOR
BULLETIN 5000 on MOTORS
BULLETIN 7000 on GRINDERS

ADAPTABILITY · LONG LIFE · ECONOMY
B LINE
POWER POISE

THE BROWN-BROCKMEYER CO

LEADING INDEPENDENT MOTOR MANUFACTURER

1030-1044 SMITHVILLE ROAD
DAYTON 1, OHIO

PLANTS AT DAYTON, WILMINGTON AND XENIA, OHIO—OFFICES IN PRINCIPAL CITIES

To Answer Your Questions About the New

TWIN DISC

Small Hydraulic Coupling

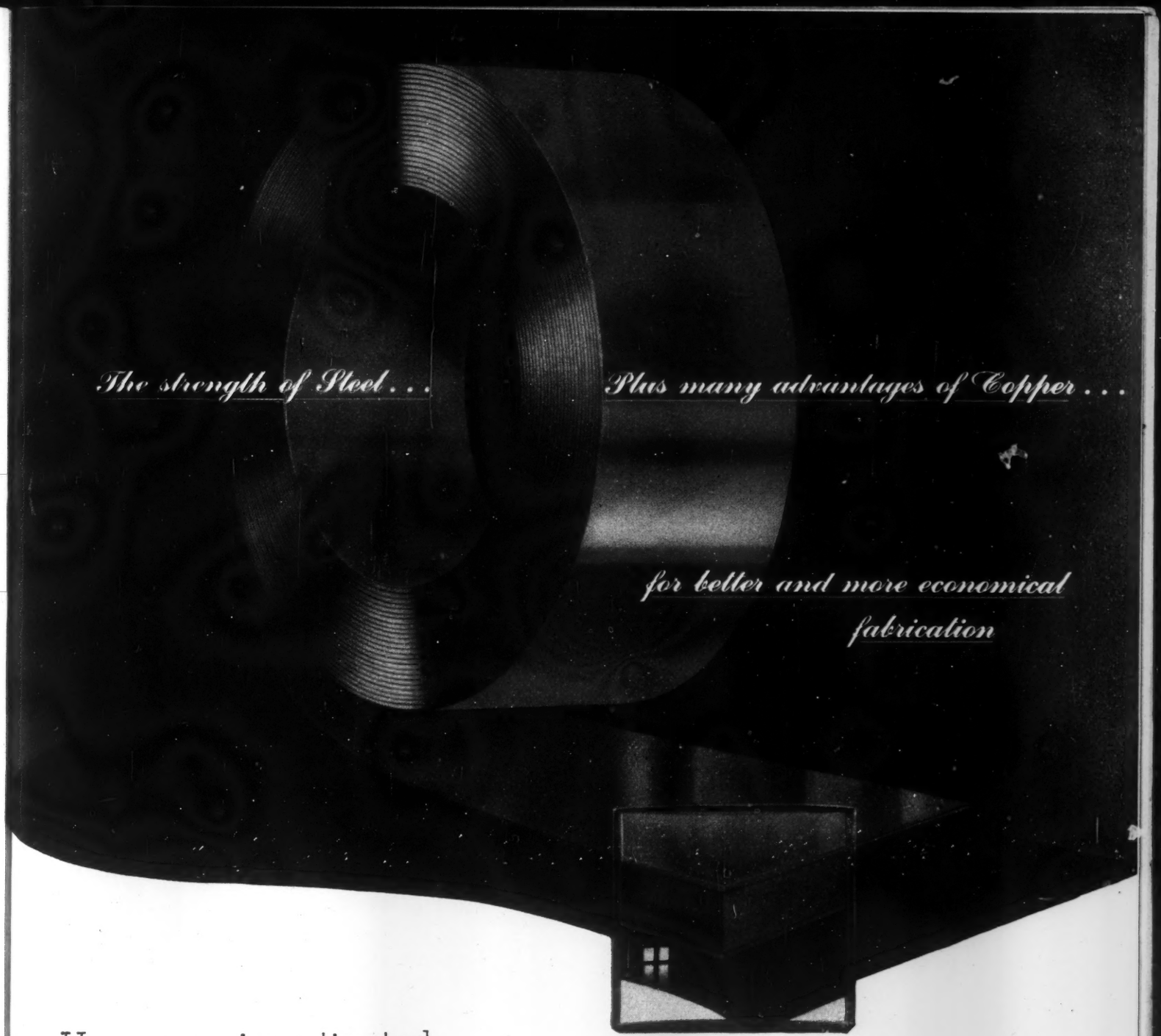
A new series of Small Hydraulic Couplings for use with one to 25 hp electric motors and internal combustion engines has been introduced by The Twin Disc Clutch Company. You will want to know all about these new couplings . . . how they can solve your particular power transmission problem.

The Small Hydraulic Coupling issue of *Production Road* explains the advantages you can gain by using these couplings . . . smooth operation . . . full torque delivery . . . no stalling. Also, use of this new unit allows the selection of an engine or motor to fit *running* requirements . . . eliminates the need for "break-and-replace" protection for driven parts.

Read how the new series already has been put to use by the Link Belt Company in its "Electrofluid Drive," a packaged power unit.

Write to the Twin Disc Clutch Company, Racine, Wisconsin, for your copy of the Small Hydraulic Coupling issue of *Production Road*. It will answer your questions about the new Twin Disc Small Hydraulic Couplings . . . will tell you how you can put to use their *proved* advantages. THE TWIN DISC CLUTCH COMPANY, Racine, Wisconsin (Hydraulic Division, Rockford, Illinois).

SPECIALISTS IN INDUSTRIAL CLUTCHES SINCE 1918



Have you investigated

the possibilities of

SuVeneer *Trademark Reg. U. S. Pat. Off.

CLAD METALS...

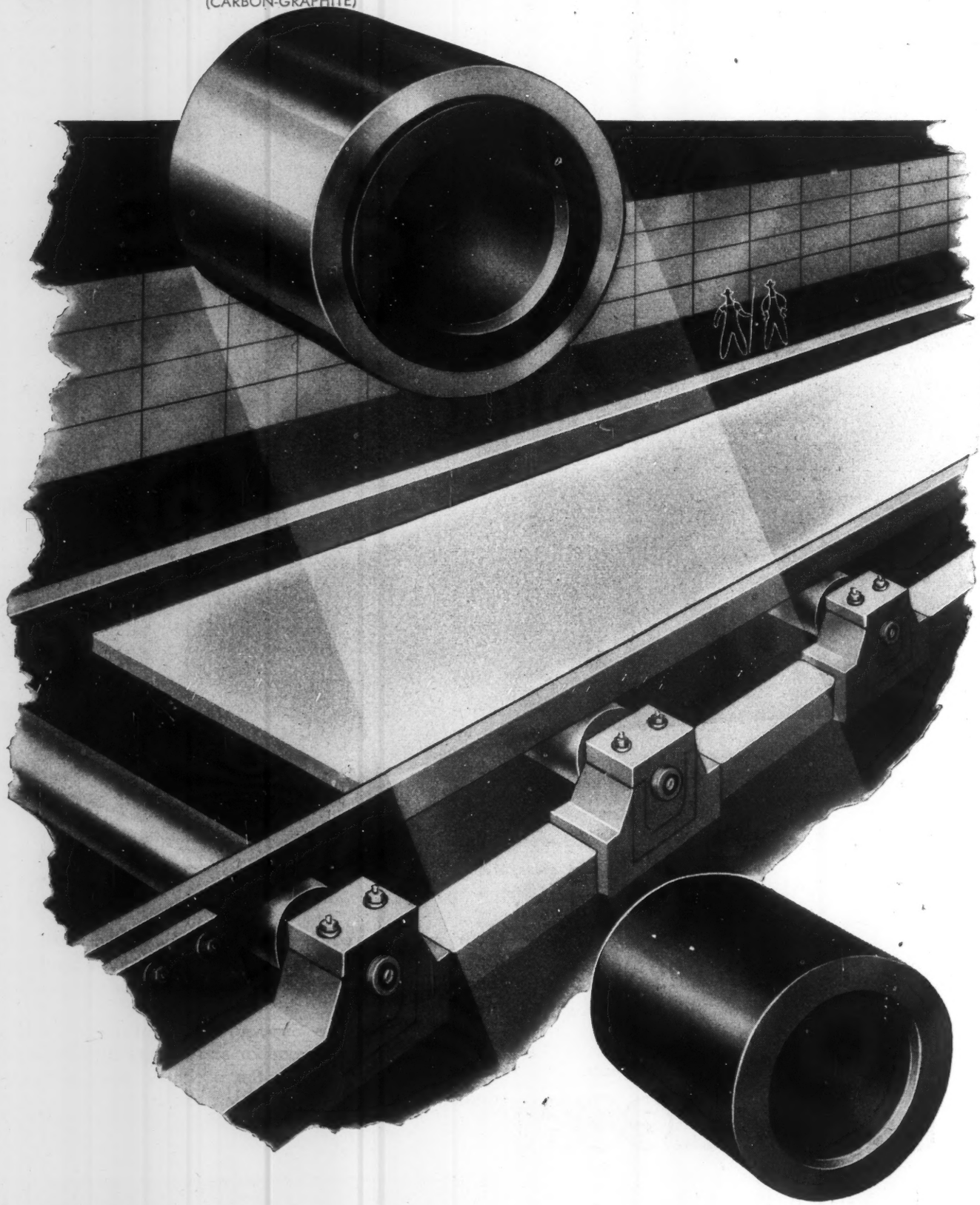
Your material requirements may reveal the need for Superior SuVeneer Copper Clad Strip, which provides a combination of the characteristics of copper and the strength and physical properties of steel.

Why not have a Superior development engineer work with you on some of your copper and copper-alloy clad metal applications, and demonstrate the economy, ease of fabrication and dependability of SuVeneer Clad Metals?

Superior Steel
CORPORATION
CARNEGIE, PENNSYLVANIA

graphitar bearings keep hot

(CARBON-GRAPHITE)



THE UNITED STATES GRAPHITE

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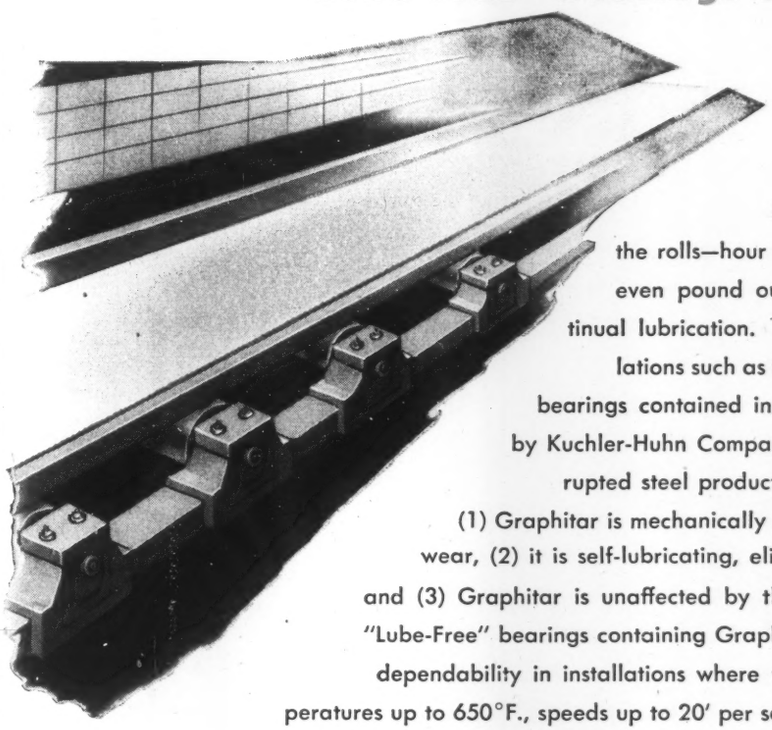
steel rolling • Intense Heat, Heavy Loads and Shock Don't Affect Friction-Free Operation of Kuchler-Huhn "Lube-Free" Bearings Containing Graphitar Liners



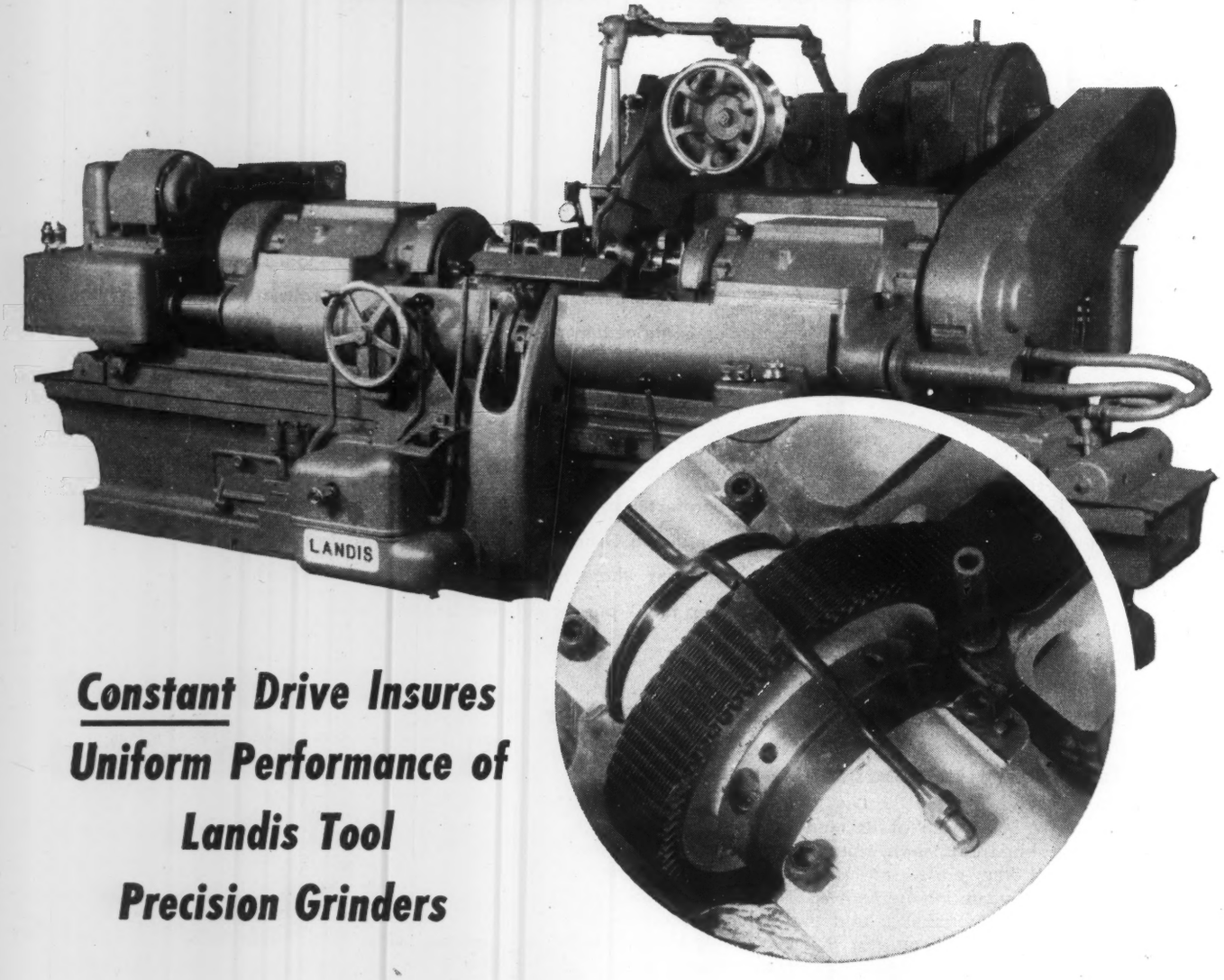
Heavy, hot rolled steel bars or plates thudding over the rolls—hour after hour and day after day—cause high wear and even pound out and fracture ordinary roll bearings despite continual lubrication. There are no such maintenance problems in installations such as the one pictured where the rolls operate on Graphitar bearings contained in housings and assembled into "Lube-Free" bearings by Kuchler-Huhn Company, Inc. These bearings help assure smooth, uninterrupted steel production at lowest maintenance and repair costs because (1) Graphitar is mechanically strong, supporting the heavy rollers with minimum wear, (2) it is self-lubricating, eliminating possibility of seizing, scoring and burning, and (3) Graphitar is unaffected by the extreme heat of the hot metal. Other "Lube-Free" bearings containing Graphitar liners are setting new records of dependability in installations where typical operating conditions include temperatures up to 650°F., speeds up to 20′ per second and bearing loads up to 250 psi projected area.

graphitar bearings, seals and other parts solve many mechanical problems

Because of its many unique characteristics, Graphitar makes ideal bearings, seals, piston liners, compressor blades, wearing rings, and other parts used in mechanisms where there are conditions of high speed, intense heat or cold, and chemical attack. Graphitar is self-lubricating, and under load takes on a high polish. It is mechanically strong. It is chemically inert. It will not melt or fuse at any temperature. We are equipped to mold Graphitar to any practical shape and to finish parts to tolerances as close as .0005" in small sizes. Send us sketches or descriptions of your products for specific recommendations and write for 44-page catalog.

COMPANY • SAGINAW, MICH.

WHITNEY
SILENT CHAIN

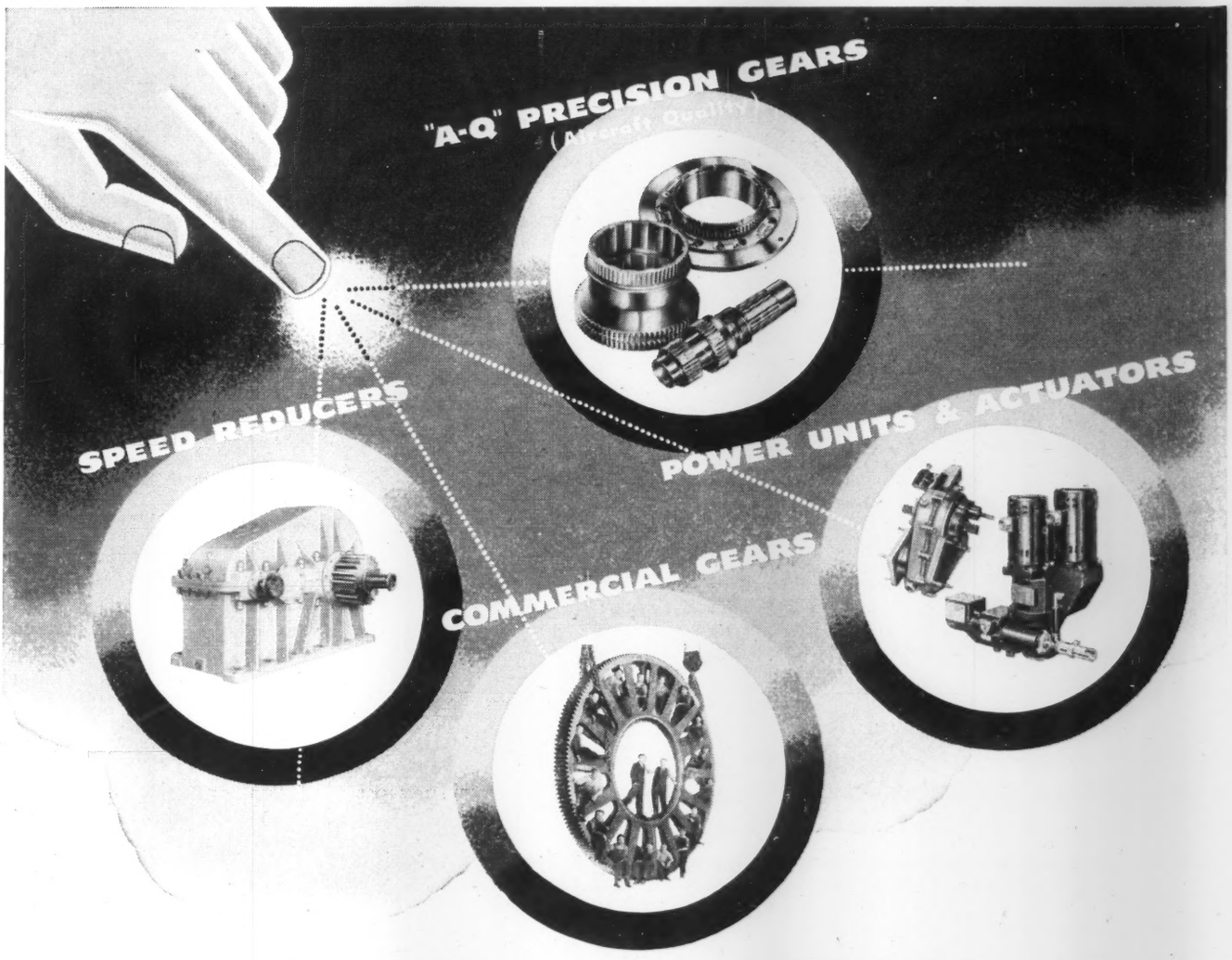


***Constant* Drive Insures Uniform Performance of Landis Tool Precision Grinders**

Landis 16″ Type DH Crank Pin Grinders (made to accommodate shafts from 32″ to 72″ in length) must grind for roundness to within .0002″; to the same tolerance for straightness; and for plane (relation of one crank pin to another) to within .002″.

By using Whitney Silent Chain—½″ pitch, 2½″ wide—*constant* machine speed is maintained at all times, thus *insuring* uniformity of performance. Designers of modern machinery *know* from years of experience they can rely on Whitney Silent Chains for powerful, accurate driving performance even under the toughest operating conditions.

THE WHITNEY CHAIN & MFG. CO.
HARTFORD 2, CONNECTICUT



Whatever your needs in power transmission . . .

Regardless of what your requirements in power transmission may be, Foote Bros. has the engineering staff—the skilled production force—the modern plant facilities—to serve you. And above all, nearly a century of experience in producing such equipment.

Today two large plants—one devoted to the manufacture of precision gears, power units and actuators; the other to the manufacture of industrial gears, speed reducers and special machinery—are serving industry. These facilities include research laboratories, a skilled engineering department and a unique heat-treating department providing absolute control so essential to modern gear production.

Whether it's "A-Q" (aircraft quality) Gears of extreme precision that offer light weight, compactness, high efficiency, capable of excessively high speed; or

—Power Units and Actuators engineered to fit your requirements—assuring the accurate mounting so essential to "A-Q" Gears; or

—Speed Reducers in a wide range of sizes and ratios to meet practically every industrial need; or

—Commercial Gears designed to fit your requirements and manufactured in quantities—any size from giants 20 feet in diameter to midgets you can hold in one hand;

—Foote Bros. engineers and Foote Bros. plant facilities are ready to meet your needs.

FOOTE BROS. GEAR AND MACHINE CORPORATION
4545 South Western Boulevard • Chicago 9, Illinois

Two engineering bulletins, one on "A-Q" gears, the other on Power Units, offer many suggestions on new developments in application of power. If you have not received copies, mail the coupon below.

FOOTE BROS.

Better Power Transmission Through Better Gears

FOOTE BROS. GEAR
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Dept.O, 4545 S. Western Blvd., Chicago 9, Ill.
Gentlemen: Please send me Bulletins on:
☐ Power Units ☐ Aircraft Quality Gears

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City..... *State*.....

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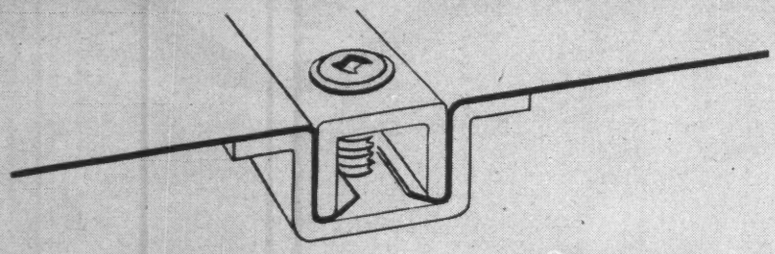
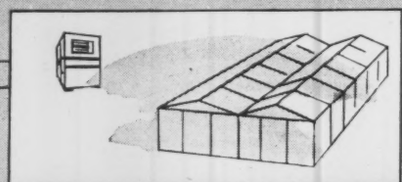
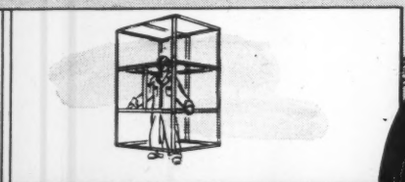
LINDSAY STRUCTURE



—and how it is put together

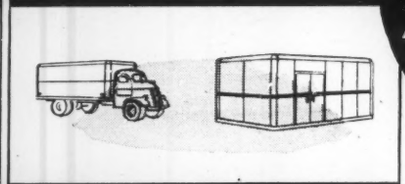


APPLICATIONS ARE UNLIMITED



LIGHT IN WEIGHT

HAS TREMENDOUS STRENGTH



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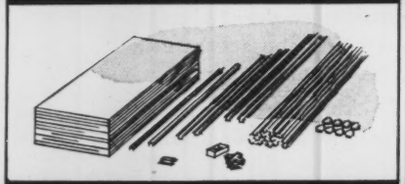
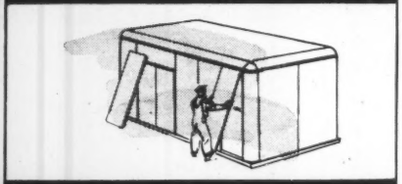


EASILY SHIPPED K-D



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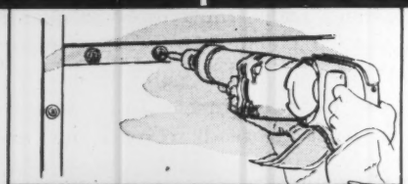


EASILY ASSEMBLED

Here's WHY it may help you solve your "Housing Problems"

If you build machines or buildings—save time—save labor—save weight, and add strength. Get new over-all economy and ease of installation. Investigate Lindsay Structure—steel or aluminum. **The Lindsay Corporation, 1742 25th Ave., Melrose Park, Ill. Sales Offices: Chicago, New York, Atlanta, San Francisco, Montreal.**

LINDSAY STRUCTURE

U. S. Patents 2017629, 2263510, 2263511
U. S. and Foreign Patents and Patents Pending

THE MODERN METHOD OF LIGHT METAL CONSTRUCTION

More *Silent* than a speck of Dirt

Quiet-Room Tests Put R&M Motors on R. C. A. Recording Machines

How *silent* can a motor be? R.C.A. engineers found out. In exacting tests of leading makes, Robbins & Myers hysteresis motors proved themselves the *quietest* of all.

These motors operate so *noiselessly* that were a grain of dirt to find its way into one of the bearings, the rattle of this *minute* particle rolling around would be heard above the motor.

It's no wonder that R & M hysteresis-type synchronous motors now power all R.C.A. *ultra-quiet* recording machines. There's no hum to cause objectionable undertones; no *vibration.* Smooth torque is transmitted to rim of plate through a soft rubber pulley.

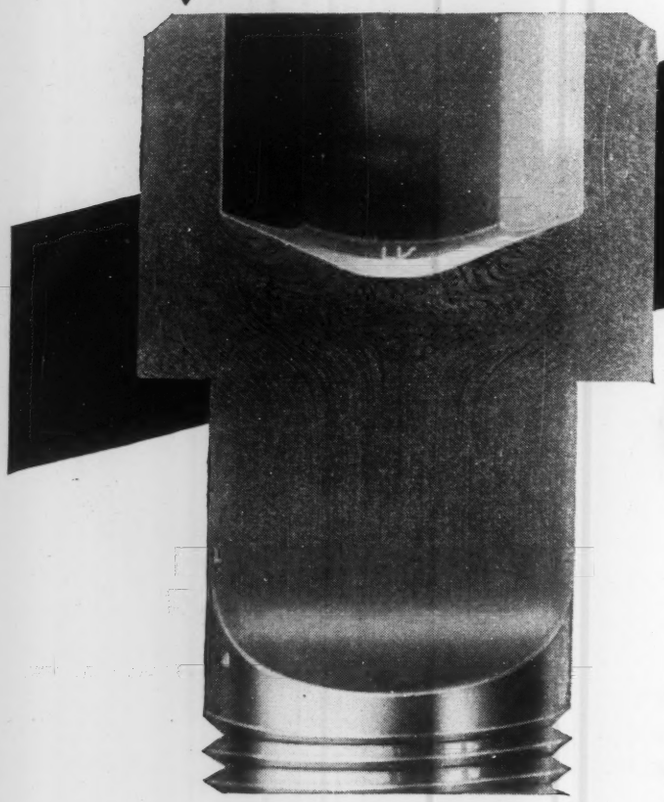
Specialized *performance* like this has well earned the Robbins & Myers reputation for meeting unusual motor needs. Whatever the service, you, too, will find R & M experience, and R & M cooperation, *short cuts* to motor satisfaction.

THIS HYSTERESIS-TYPE R&M SYNCHRONOUS MOTOR OPERATES R. C. A. SUPER-QUIET RECORDERS

ROBBINS & MYERS · INC. MOTOR DIVISION · SPRINGFIELD, OHIO
In Canada: Robbins & Myers Co., of Canada, Ltd., Brantford, Ont.

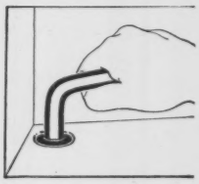
MOTORS · HOISTS · CRANES · MACHINE DRIVES · FANS · MOYNO PUMPS · FOUNDED 1878

UNRETOUCHED PHOTO ETCHED CUTAWAY
HOLO-KROME SOCKET HEAD CAP SCREW



Completely Cold Forged

INTERNAL WRENCHING



. . . . THE BETTER FASTENING METHOD

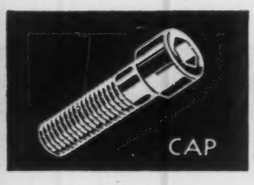
Exclusively Holo-Krome! Continuous Fibres running from end to end — uninterrupted, unbroken and unsevered! Accomplished exclusively by the Holo-Krome patented method of Completely Cold Forging and sold thru Holo-Krome Industrial Supply Distributors under the registered trade mark name "FIBRO FORGED" Socket Screws . . . Specify "Holo-Krome" and get these guaranteed unfailing performance Socket Screws.

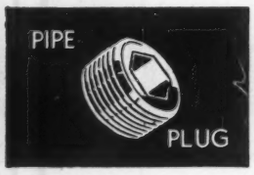
THE HOLO-KROME SCREW CORP.
HARTFORD 10, CONN. U. S. A.

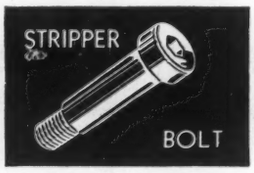
HOLO-KROME

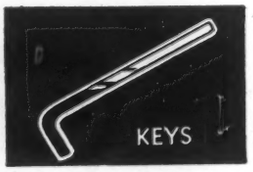
fibro forged

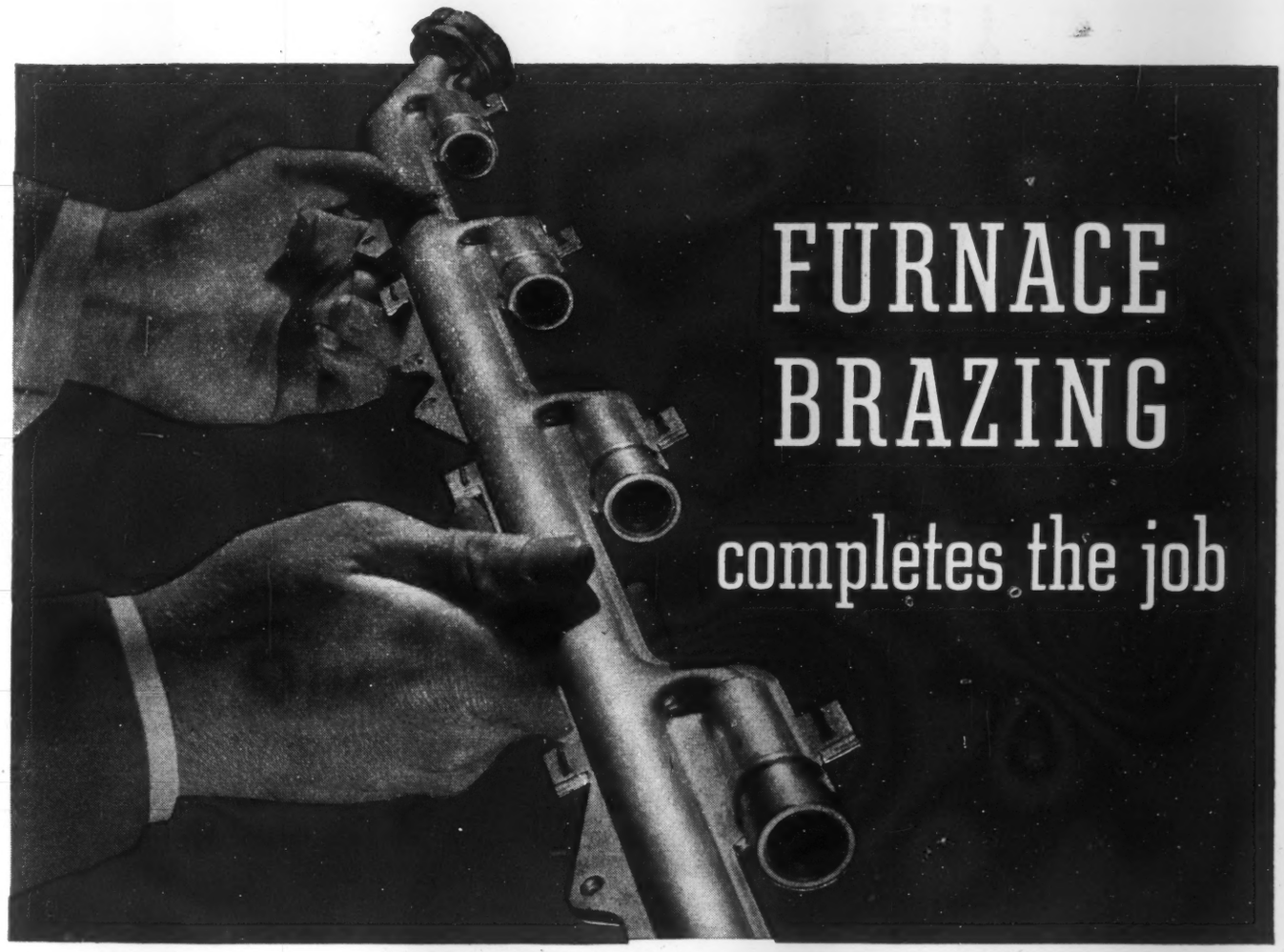
INTERNAL **SOCKET SCREWS** WRENCHING











The two halves of this cable conduit are stamped out of Alcoa Aluminum Brazing Sheet. Placed face to face, the pipe couplings are added, and the assembly is held tightly together. Then into the furnace it goes, to be brazed into a solid unit . . . a quick, simple operation.

This part is made of a heat-treatable Alcoa Aluminum Alloy. It is quenched right from the brazing furnace, giving the necessary stiffness and strength. Thus, they avoid a reheating operation, further cutting the cost of production.

If you need information or help on furnace-brazing the things you are making of aluminum, write to ALUMINUM COMPANY OF AMERICA, 1940 Gulf Bldg., Pittsburgh 19, Pennsylvania, or telephone our nearest sales office.

MORE people want MORE aluminum for MORE uses than ever

ALCOA FIRST IN ALUMINUM

IN EVERY COMMERCIAL FORM

Here is one of the latest model vertical air compressors specifically designed for continuous, heavy-duty, 24-hour per day service. One of its chief advantages is the small floor space it requires. Yet its efficiency demands consistent, dependable power. To develop the power needed, the designer specified a Dayton V-Belt Drive.

This is another outstanding example of the flexibility of Dayton V-Belt Drives. And the ability of Dayton V-Belts to perform in excess of standard requirements under all operating conditions . . . unaffected by dust, oil, heat, liquids . . . is another of the many reasons why more industrial designers consistently specify Daytons for original equipment.

A Dayton Power Transmission Specialist is ready to help you. Call or write THE DAYTON RUBBER MANUFACTURING CO., DAYTON 1, OHIO.

TWO CATALOG MUSTS FOR INDUSTRIAL DESIGNERS

Catalog No. 280—a 384-page encyclopedia of V-Belt information listing millions of power drive combinations.

* *

Catalog No. 150—contains complete information on fractional horsepower drives.

Dayton Rubber

THE MARK OF TECHNICAL EXCELLENCE IN NATURAL AND SYNTHETIC RUBBER

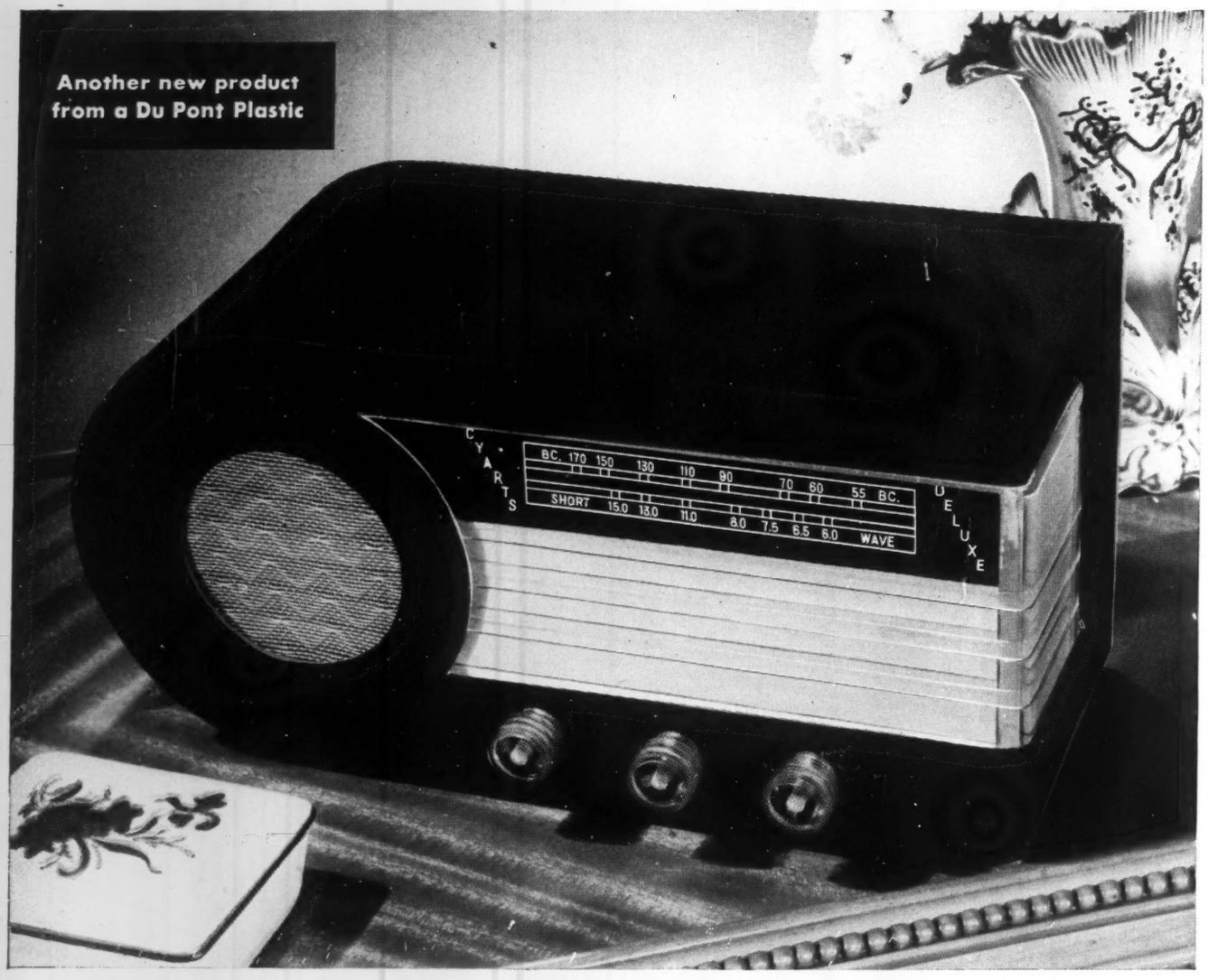
THE WORLD'S LARGEST MANUFACTURER OF V-BELTS

Among the many invaluable properties of stainless steel, you must give high rank to its great resistance to heat. We've gone on from there, too, and developed *super-alloy* steels in that field. Is heat-resistance a problem of yours—either in your product or your equipment? If so, investigate Allegheny Metal *NOW*. Production facilities are being steadily increased to meet the demand for it—therefore *now's the time* for you to think, plan and work with stainless for the future. ● Let's get our engineers together.

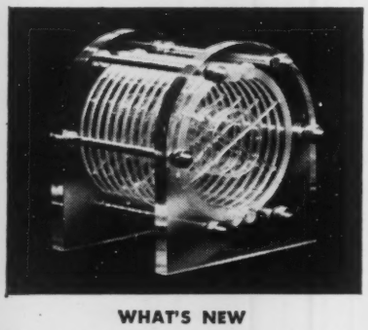
ALLEGHENY LUDLUM STEEL CORPORATION, PITTSBURGH 22, PA.

Pioneers in Specialty Steels

CALL FOR AN ALLEGHENY LUDLUM ENGINEER



TONE'S RIGHT... COLOR'S BRIGHT... CABINET IS DU PONT "LUCITE"



WHAT'S NEW

This "dialyser" made of Du Pont "Lucite" enables scientists to observe more easily the progress of experiments. With this transparent unit, they can keep a constant watch on various processes, such as removing acids, recovering soluble salts, and separating colloidal materials. It's a new idea in laboratory equipment... made possible by the clarity, light weight, and chemical inertness of "Lucite."

Yes... you can now get rich tone and brilliant color both in the same radio. That is the newest accomplishment of Du Pont "Lucite."

The makers of the striking superheterodyne radio shown here selected Du Pont "Lucite" not only for its unusual beauty and glowing colors, but also for the ample, resonant tonal quality it assures as a cabinet material.

"Lucite" acrylic resin has good tensile and flexural strength, and is shatter-resistant. The excellent optical qualities of "Lucite" are evidenced in its ability to "edge-light," permitting unusual illumination effects. "Lucite" is light in weight and can be readily and economically fabricated.

This use of "Lucite" is one further evidence that a manufacturer — in any field — who knows what each Du Pont plastic can do, stands an ever better chance of turning his ideas into marketable products. Write for literature. E. I. du Pont de Nemours & Co. (Inc.), Room 391, Arlington, N. J.

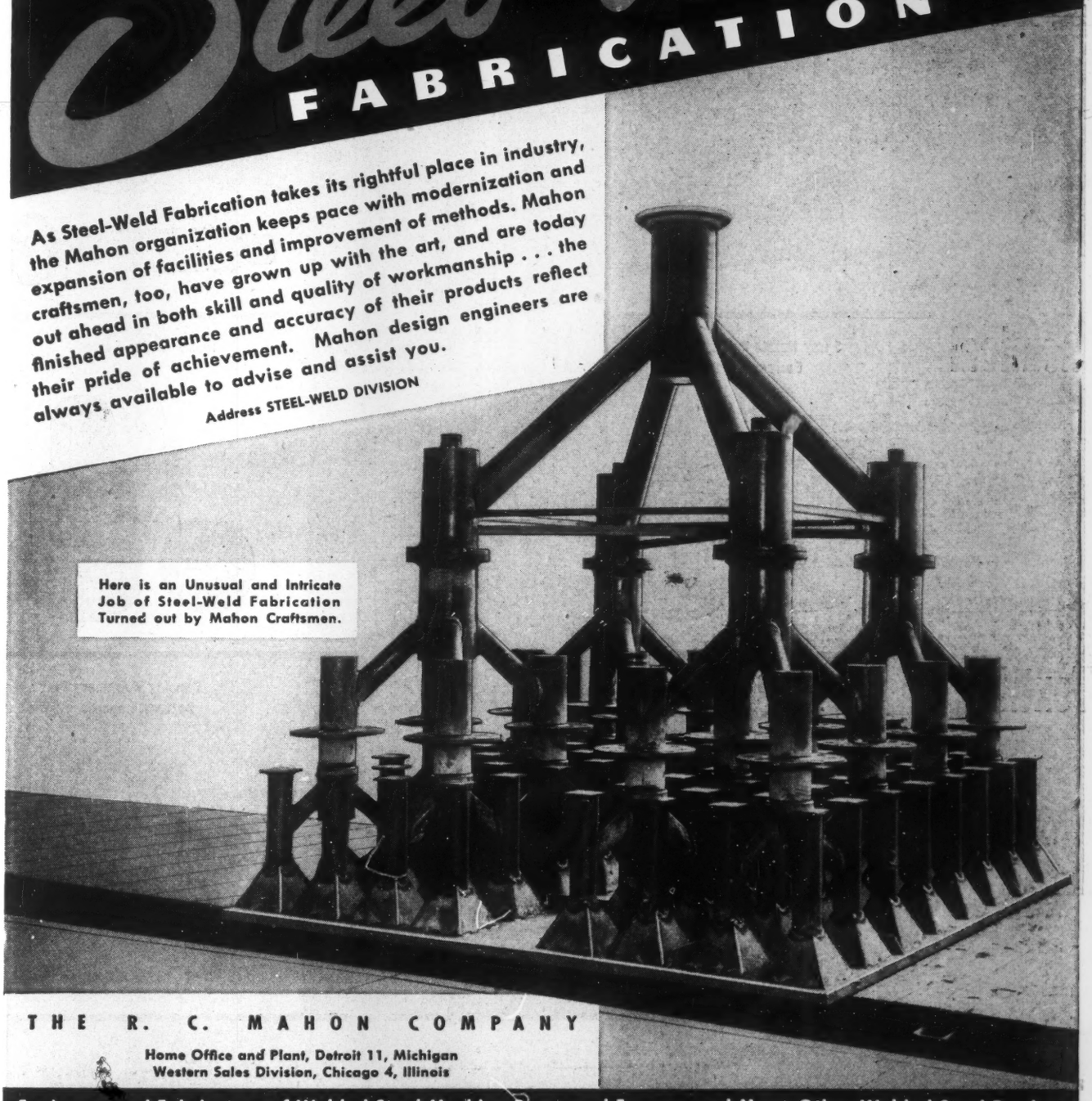
The radio shown is made by Cyart Plastics, Inc., Bronx, New York. The cabinet is hand-fabricated from sheets of colored and transparent Du Pont "Lucite."

DU PONT
Plastics
BETTER THINGS FOR BETTER LIVING
...THROUGH CHEMISTRY

Steel-Weld FABRICATION

As Steel-Weld Fabrication takes its rightful place in industry, the Mahon organization keeps pace with modernization and expansion of facilities and improvement of methods. Mahon craftsmen, too, have grown up with the art, and are today out ahead in both skill and quality of workmanship . . . the finished appearance and accuracy of their products reflect their pride of achievement. Mahon design engineers are always available to advise and assist you.

Address STEEL-WELD DIVISION



Here is an Unusual and Intricate Job of Steel-Weld Fabrication Turned out by Mahon Craftsmen.

THE R. C. MAHON COMPANY

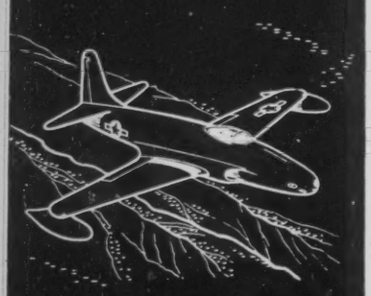
Home Office and Plant, Detroit 11, Michigan
Western Sales Division, Chicago 4, Illinois

Engineers and Fabricators of Welded Steel Machine Bases and Frames, and Many Other Welded Steel Products

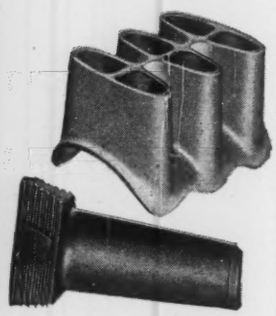
MAHON

throughout industry

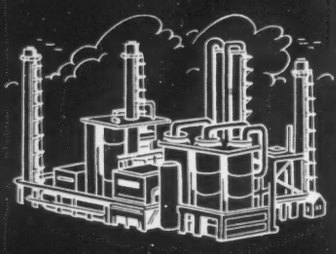
Aircraft



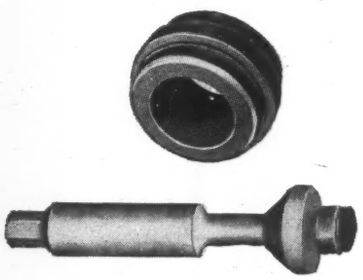
Parts for Jet and Conventional Airplanes



Petroleum

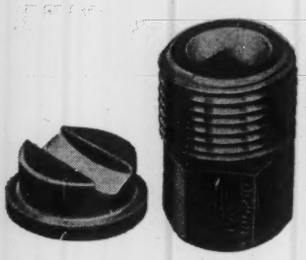


Valve Parts Used in Petroleum Refinery

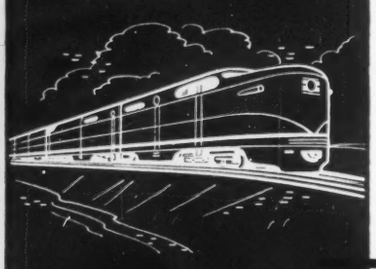


Chemical

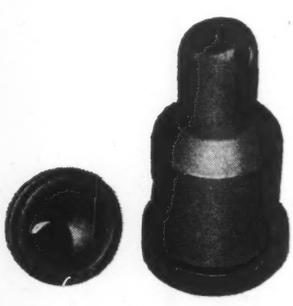
Spray Nozzle Parts for Handling Corrosive Chemicals



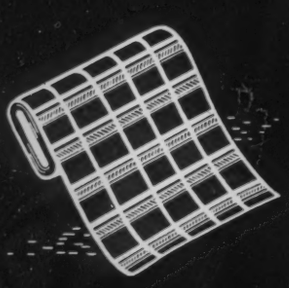
Diesel Engines



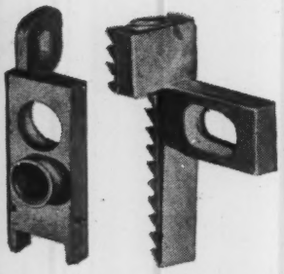
Diesel Engine Parts



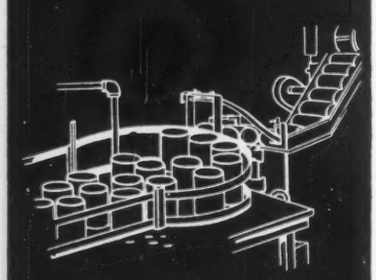
Textile



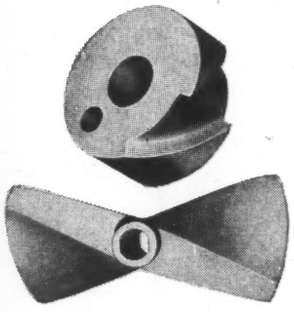
Left: Cloth Cutting Slide
Right: Sewing Machine Feed Dog



Food Processing

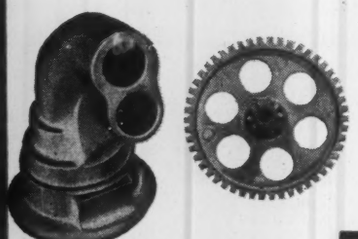


Top: Canning Machinery Part
Bottom: Impeller



Metalworking

Left: Scarfing Blowpipe Head



Right: Gear for Steel Mill Pickling Tank

HAYNES TRADE-MARK *alloys*

HAYNES precision castings

MEET THE TOUGHEST SERVICE CONDITIONS

You can now specify parts produced from alloys that dominate the field where high strength and resistance to heat, corrosion, and abrasion are required. Parts can be engineered for performance rather than convenience of fabrication, since intricate parts can be produced economically by the HAYNES precision casting process. HAYNES precision castings are uniform in quality, size, contour, and finish.

In many industries HAYNES precision castings are solving difficult problems of design, fabrication, and materials. For more complete information, write to any district office for your copy of the booklet, "HAYNES Precision Castings." Our engineers will be glad to discuss with you the possibility of producing your parts by this new method.

The registered trade-marks "Haynes," "Haynes Stellite," "Hastelloy," "Hascrome," and "Multimet" distinguish products of Haynes Stellite Company.

You Can Obtain Precision Castings of these HAYNES Alloys

HAYNES STELLITE TRADE-MARK

Cobalt-chromium-tungsten alloy for resistance to wear, heat, and corrosion

HASTELLOY TRADE-MARK

High-strength nickel-base alloy for resistance to heat and corrosion

HASCROME TRADE-MARK

Iron-base composition for resistance to wear and impact

MULTIMET TRADE-MARK

Cast or wrought heat-resistant alloy

HAYNES Precision Castings are also available in Type 303, Type 316, Type 310, Type 347, Type 410, Type 440-C, and other AISI grades of stainless steel, containing 12 per cent or more chromium.

Haynes Stellite Company

Unit of Union Carbide and Carbon Corporation

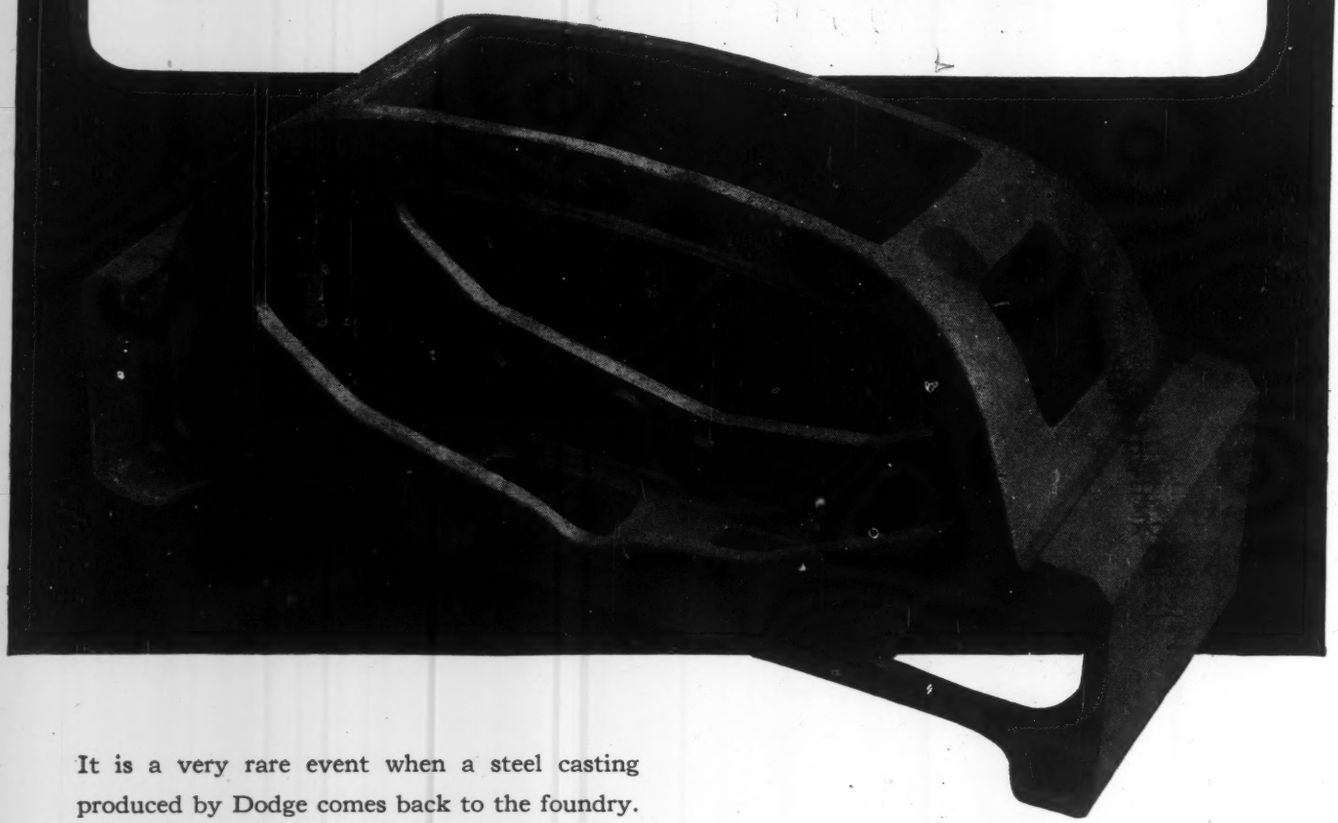
UCC

General Offices and Works, Kokomo, Indiana

Chicago—Cleveland—Detroit—Houston—Los Angeles—New York—San Francisco—Tulsa

They travel on

ONE-WAY TICKETS



It is a very rare event when a steel casting produced by Dodge comes back to the foundry.

In fact, so far as we know, our percentage of customer returns averages the lowest in the industry.

The men here are trained, and the foundry techniques they use are planned, to produce sound castings in the mold, free from internal flaws or voids, and free from surface blemishes.

As a result, users of Dodge Castings save money in finishing and assembly, and turn out better, stronger, longer-wearing products.

That old one about the chain and its weakest link is still true. We see to it that the weakest link is never a steel casting made by Dodge.

When would you like to discuss it with us?

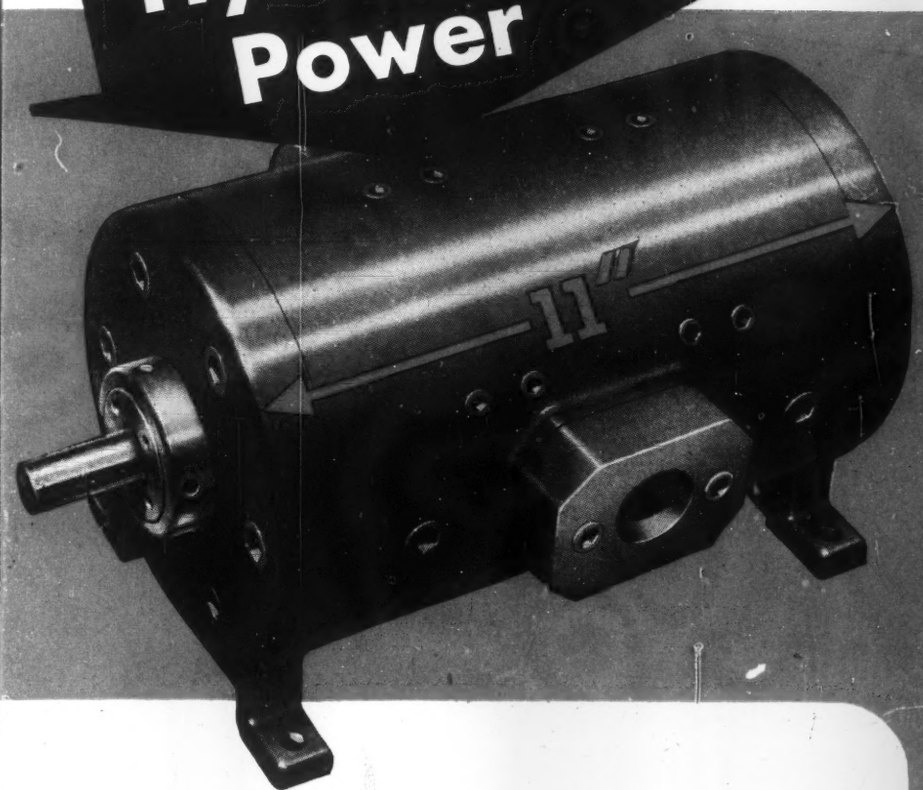
DS

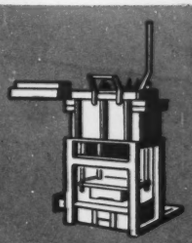
DODGE STEEL CASTINGS

DODGE STEEL COMPANY • TACONY, PHILADELPHIA 35, PA.

EXTRA Hydraulic Power *when you need it*

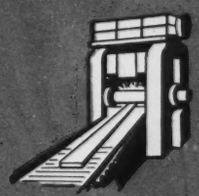
FOR





Concrete Block-Making Machinery

Hydraulic Presses



Steel Mill Equipment

Road Grading Machinery

Dump Trucks

Airplanes

Bulldozers

The New Hydro-Power Booster gives you a two-stage System at a remarkably low cost*

You can get pressures up to three times the rating of your present pump—as high as 7,500 psi—by valving its discharge through a Hydro-Power Booster. Step up your 1,000 lb. pressure to 3,000 lbs. when you need it—it's as easy as that!

This new hydraulic power converter functions as a highly-efficient second stage for any hydraulic pump. It will give you the added pressure—when you need it. Ram diameters in newly designed machinery can be reduced to ⅓ previous areas and thus rapid traverse at low pressure can be obtained. With the Hydro-Power Booster you'll cut original equipment cost, and get the extra hydraulic power you need.

For complete information use the handy coupon.

HYDRO-POWER, INCORPORATED
Belmont and Sheridan Aves., Springfield, Ohio

**For only $335, the cost of the Hydro-Power Booster, you can get pressures up to three times your present system.*

AND

- Extrusion Machines
- Oil Extraction Machinery
- Snow Plows
- Scarifiers
- Material Handling Equipment
- Baling Machines
- Plastics Molding Machinery
- Die Casting Machinery
- Heavy Duty Jacks

hydro power

hydraulics

FOR DEPENDABLE PACKAGED POWER

Hydro-Power, Inc.
Belmont and Sheridan Aves:
Springfield, Ohio

Yes! Send me information on the new Hydro-Power Booster.

Name_____ Title_____

Company_____

Street_____

City and Zone_____ State_____

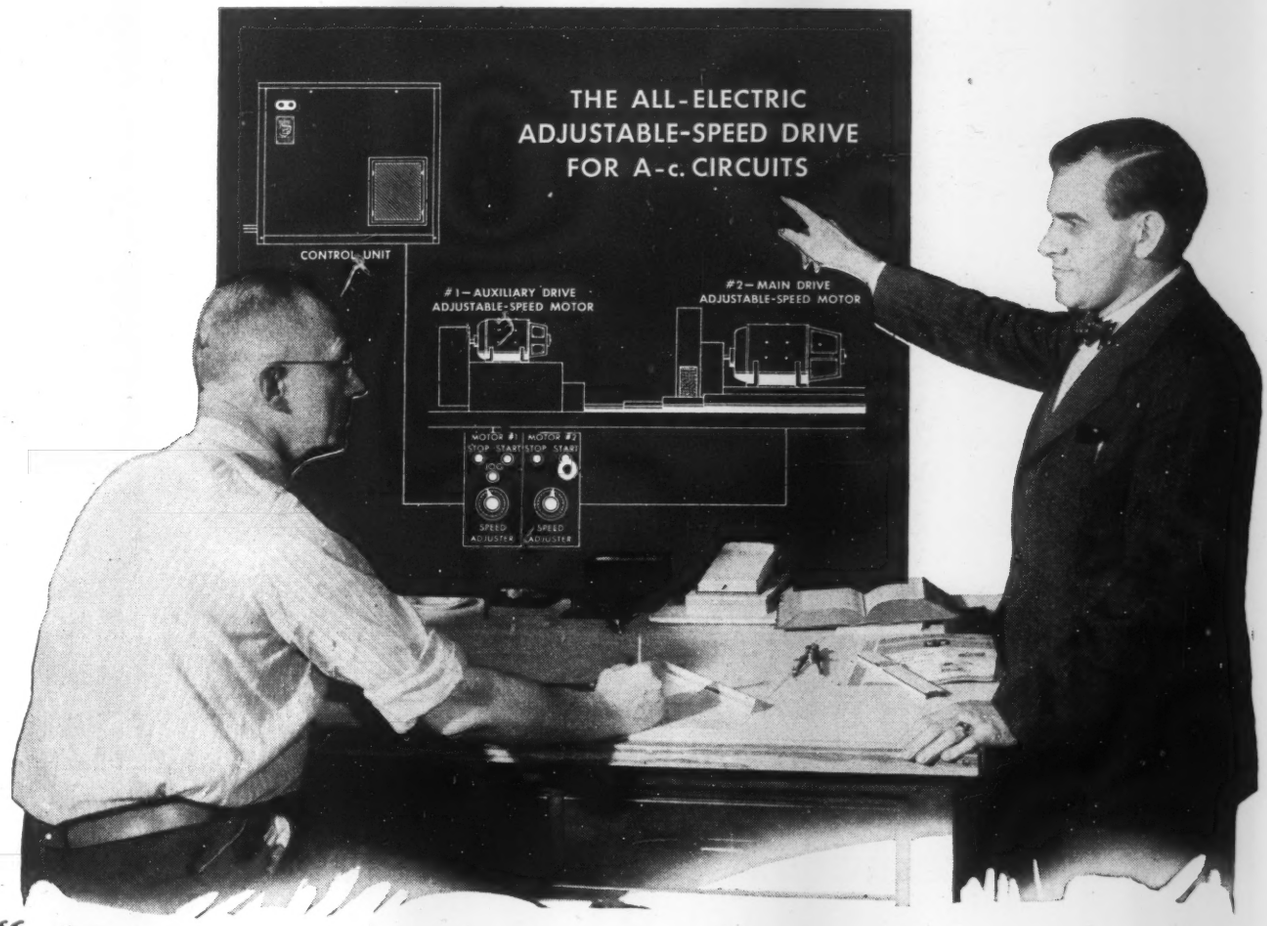
So much more...for so little more

AMERICA'S SUPER FINE BALL BEARING

30% More Load · 30% Longer Life
Silent Operation
Extreme Precision
Supreme Performance
Each Bearing Radio Tested
Used in America's Finest Machines

HOOVER *The Aristocrat of Bearings*

HOOVER BALL AND BEARING COMPANY, ANN ARBOR, MICHIGAN



"Here's your Answer TO UNLIMITED SPEED SELECTION!"

RELIANCE V★S DRIVE

Conveniently-packaged, space-saving V★S Drives are available from 1 to 200 horsepower.

Reliance V★S is the *All-electric, Adjustable-speed Drive,* which operates from *A-c. Circuits.* The flexibility it brings to machine operations can increase your production and cut your costs—as it has already done in thousands of installations. Here is the simplest, most efficient means of securing an infinite range of stepless speed changes from your plant's A-c. circuit for all processing jobs. Bulletin 311 will bring you more of the important facts about the V★S Drive. Write for it today!

RELIANCE ELECTRIC & ENGINEERING CO.
1079 Ivanhoe Road • Cleveland 10, Ohio

Appleton, Wis. • Birmingham • Boston • Buffalo • Chicago • Cincinnati • Denver • Detroit • Gary • Grand Rapids • Greenville Houston • Kansas City • Knoxville • Los Angeles • Milwaukee • Minneapolis • New Orleans • New York • Pittsburgh Portland, Ore. • Rockford • St. Louis • San Francisco • Seattle • Syracuse • Tampa • Tulsa • Washington, D. C. Sao Paulo, Brazil

RELIANCE A-C D-C MOTORS

"Motor-Drive is More Than Power"

SEAMLESS and WELDRAWN* *Stainless Steels • Alloy Steels Carbon Steels • Nickel & Inconel Monel • Beryllium Copper*

Superior tubing *must* have what it takes, judging from the demands of the manufacturers of quality peacetime products. Many of these same manufacturers were engaged in production for the armed forces, where quality took on a new meaning—lives, many lives depended on it.

Quality can't be "just skin deep"—it must pervade the innermost parts of a product. Tubing usually loses its identity in end use—it very often is just a "line on a blueprint"—but a line or part that must perform as well as the costliest component in the assembly.

Choosing the proper analysis depends upon combinations of such properties as corrosion resistance, formability, machinability, high strength at high temperature and surface finish. Superior maintains tireless control of these factors as well as physical dimensions and tolerances, all of which contribute to tubing quality. Our ability to predict accurately the results to be experienced with any given analysis, is your assurance of enduring, faultless performance in production and end use.

Superior engineers and metallurgists are ready to help you choose the exact analysis for your product. Design with Superior tubing and be sure!

*Registered U. S. Trademark

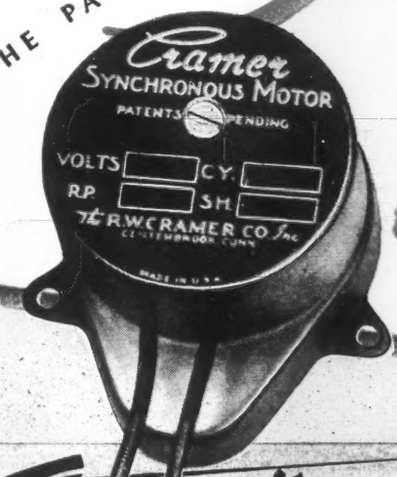
THE BIGGER NAME IN SMALL TUBING Superior

see our CATALOG in SWEET'S FILE for PRODUCT DESIGNERS

SUPERIOR TUBE COMPANY
Norristown, Pennsylvania

PRECISION-POWER

IN THE PALM OF YOUR HAND



NEW

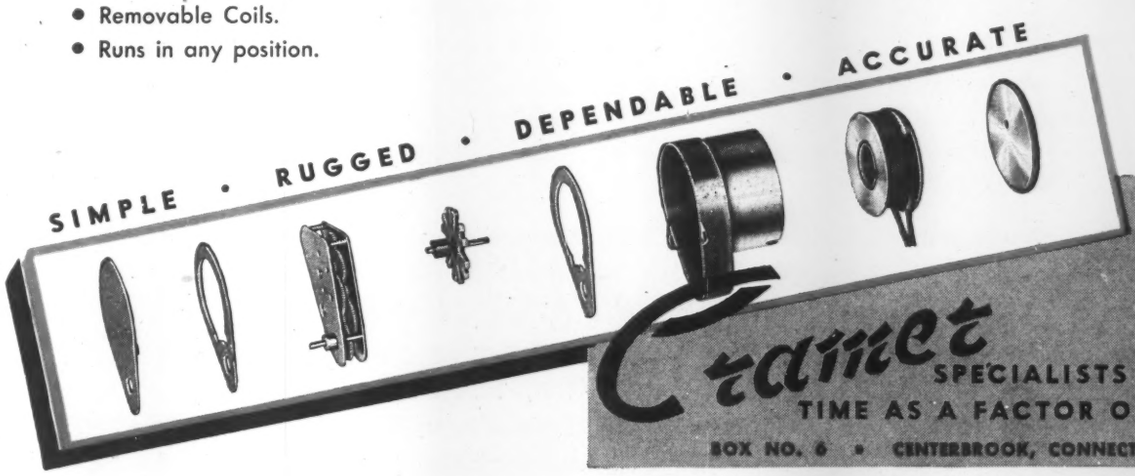
Cramer SELF STARTING SYNCHRONOUS TIMING MOTOR

WITH THESE SPECIFIC POINTS OF DESIGN AND PERFORMANCE SUPERIORITY

- Small Physical Size—2⅜ x 2⅛ x 1½.
- Extremely High Torque—30 in. ozs. at 1 r.p.m.
- Low Input—2.7 watts at 115 or 230V. 60 Cy.
- Average Heat Rise—30°C at rated voltage.
- Low Rotor Speed—240 r.p.m. at 60 Cy.
- Precision Cut—interchangeable gear trains.
- Twenty-eight Speeds—60 r.p.m. through 1/24 r.p.h.
- Ample sealed in Lubricant.
- Removable Coils.
- Runs in any position.

Designers and builders of high grade instruments . . . including ourselves . . . have long looked for a real precision built motor combining the above important features and performance characteristics. This new Cramer Self-starting Synchronous Motor is exactly what you have been looking for. 60 cycle available now. Later production also planned on 25 and 50 cycle. Write us at once for further details outlining your specific requirements.

SIMPLE • RUGGED • DEPENDABLE • ACCURATE



Cramer SPECIALISTS IN TIME AS A FACTOR OF CONTROL

BOX NO. 6 • CENTERBROOK, CONNECTICUT

NOW

PEASE "H22" BLUEPRINTING MACHINE WITH SINGLE LIGHT SOURCE EQUALS SPEED OF MULTIPLE ARC LAMP PRINTERS

PEASE "H22-W" *Continuous Blueprinting and Processing Machine. Made in 42" and 54" sizes.*

95 WATT TUBE PRODUCES MAXIMUM PRINTING SPEED PLUS UNIFORM LIGHT DISTRIBUTION OVER ENTIRE WIDTH

PEASE "H22" Continuous Blueprinting Machine with 95 Watt Tube prints steadily and evenly over the entire surface at speeds up to 30 feet per minute. When used in conjunction with the Pease "W" Processor it produces highest quality finished prints, ready for use, at corresponding speeds and low per square foot cost.

STREAMLINED with typical Pease simplicity of design and finished in new wrinkle finish grey and black, this superior blueprinting equipment, Pease "H22-W," possesses many famous Pease features such as Sliding "Vacuum-Like" Contact which smooths out tracings and prevents errors; Floating Water Wash which prevents tension, wrinkles and bleeding; Quick Change Chemical Applicator that allows 30 seconds change from Blueprints to Negatives; Five 8-Inch Drying Drums which economically produce prints flat as hung wallpaper; plus ready accessibility and extreme ease of operation.

Write for complete details, specifications and prices . . . No obligation, of course.

THE C. F. PEASE COMPANY
2606 WEST IRVING PARK ROAD
CHICAGO 18, ILLINOIS

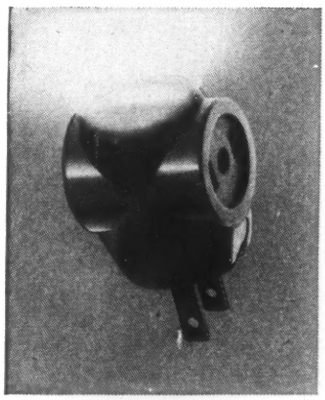
LEADING MANUFACTURERS OF TRACING REPRODUCTION MACHINES SINCE 1907

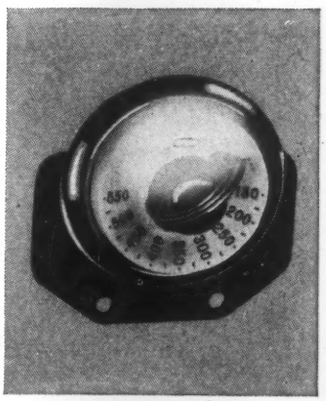
It talks back to 'Big Shots'

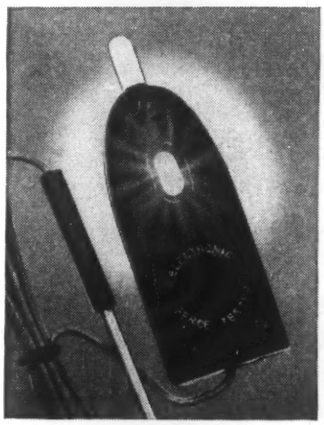
You can set this new pint-size dictation instrument on your desk and whittle down that stack of tardy correspondence—or tuck it under your arm and take it home to record your favorite broadcast or Junior's clever sayings. It's the "Audograph," made by the Gray Manufacturing Co. of Hartford, Conn.

Note the G-E Neon Glow Lamp under the clear plastic cap just to the right of the adjusting knob. It is connected in the output of the voice amplifier and lights up to indicate that recording is progressing. *Only an electrical discharge lamp such as this G-E Glow Lamp could do the job.*

-and it has a message for you!







TWO NEW G-E INDICATOR LAMPS

for 220-volt industrial power circuits, AC or DC.

NE 56 — 1-watt, with standard screw base

NE 58 — ½-watt, with candelabra screw base

Featuring unusual resistance to vibration and shock.

TYPICAL new products improved with G-E Glow Lamps are pictured here. They merely hint at hundreds of other unbelievably low cost applications on home appliances, wiring devices, and many types of equipment. Why not consider the following sales features of G-E Glow Lamps on *your* new products:

1. Distinctive orange red glow, needs no cover glass.
2. Dependable long life—rated at 3,000 hours.
3. Very low current consumption.
4. Variety of sizes and wattages.
5. High resistance to vibration and shock.
6. Usable on AC or DC circuits.
7. Works on regular 105-125 volt circuits without the use of step-down transformers.
8. Practically no heat.

FREE FOLDER *describes typical uses for G-E Neon Glow Lamps and gives lamp data. Write address below.*

G-E LAMPS

GENERAL ELECTRIC

Nela Specialty Div. Lamp Dept., 1 Newark St., Hoboken, N. J.

Fixed Nuts Stay Put–BUT

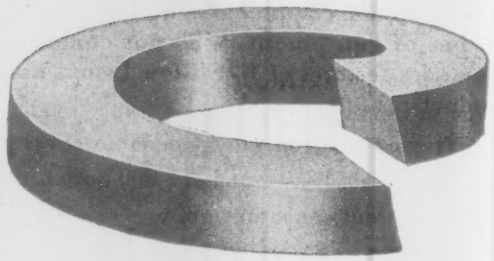
Even if your bolted assembly needs a fixed nut—remember that vibration and wear will loosen all other parts unless you use a strong spring washer to expand and hold all parts tight as wear occurs.

True, a good fixed nut will not move up or down on a bolt;—but the other parts of bolted assemblies inevitably loosen because of bolt stretch, the frictional wear of metal on metal, burrs, flares, and the pulverizing of paint, scale and rust.

A live spring washer—a long-range spring washer—is absolutely essential if you expect your whole assembly to be held tight as wear occurs. The expanding spring action keeps up the pressure on all parts as friction loosens them.

No matter what kind of nut you use—fixed or standard—be sure to specify a Kantlink spring washer. There is no substitute.

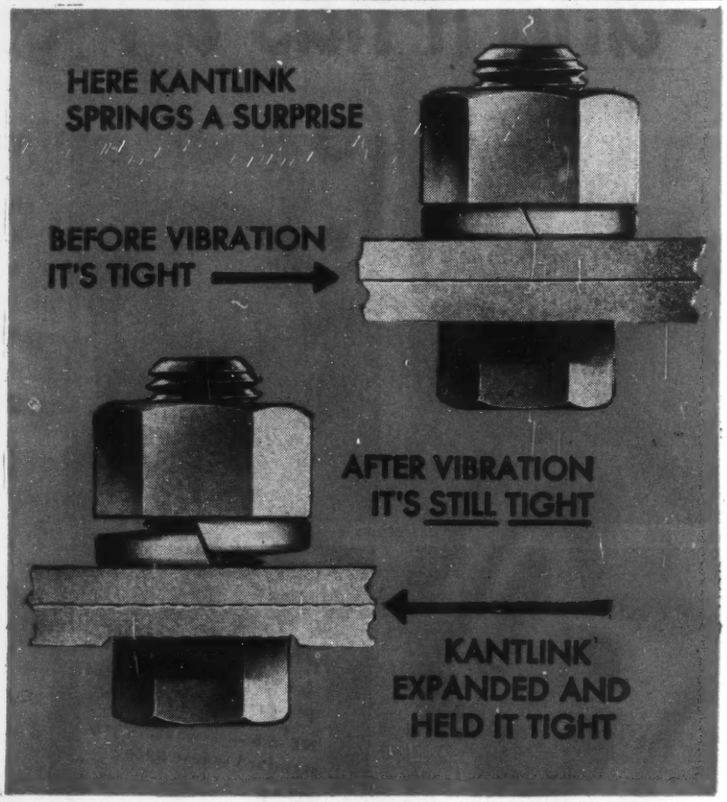
Originators of Kantlink the long-range spring washer.



Originators of

KANTLINK™

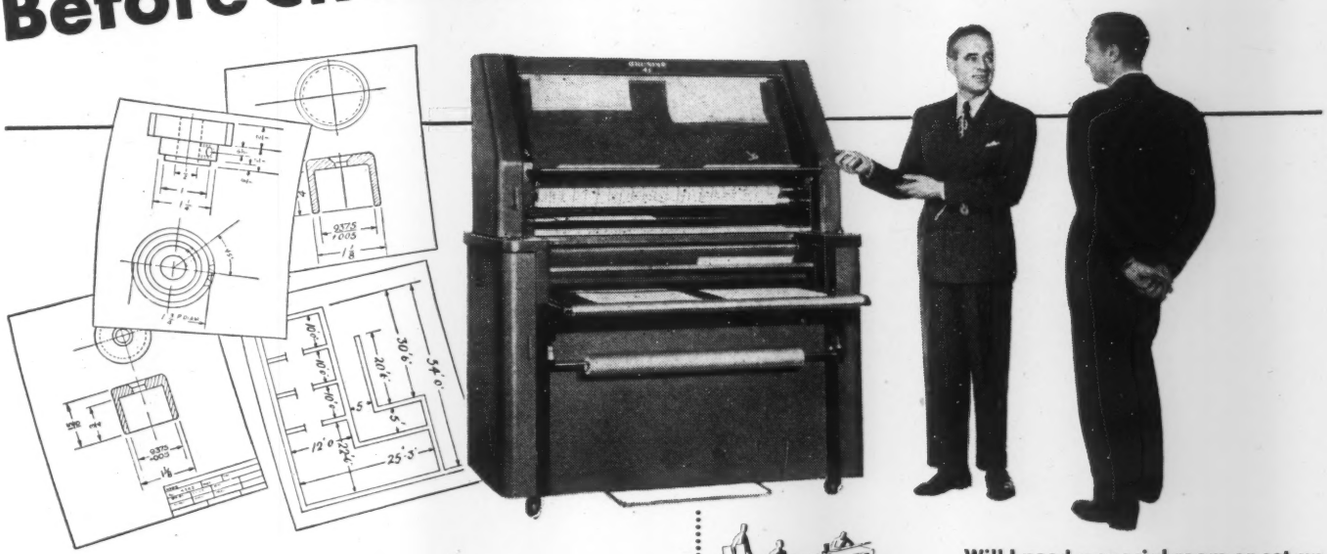
the long-range spring washer

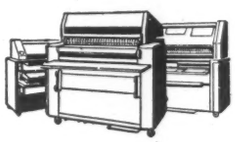


THE NATIONAL LOCK WASHER COMPANY

Newark 5, New Jersey — Milwaukee 2, Wisconsin

What FACTS Should YOU Have Before Changing to Black Line Prints?





Will black line equipment meet my future print requirements, as well as my present ones?

Yes—whether you use only a few prints a day—or hundreds—there are Bruning BW Printer-Developers to meet your needs. Whatever size you choose, you get all the advantages of Bruning BW Black and White Prints—made directly from your tracings, without the use of a negative, and in *seconds*.

How can I tell which printer-developer is best for my needs?

Bruning offers you 45 years of experience in analyzing print requirements. Bruning representatives will not recommend a Printer-Developer which is larger or smaller than you need. All recommendations are based on a careful study of your individual print uses.

Will I need a special room or set-up for Bruning BW Equipment?

Not unless it seems desirable from an efficiency standpoint. Bruning BW Printer-Developers require no plumbing. There are no exhaust fumes to provide for. Bruning BW Printer-Developers can therefore be installed anywhere in your drafting or engineering department. The BW Direct Line Printing process is clean and so simple that even an inexperienced operator can make good BW Prints.

You Get These Six Major Advantages with the BRUNING BW SYSTEM

1. **A versatile, simple method for making black or colored line prints directly from transparent or translucent originals.**
2. **45 years' experience in analyzing printmaking needs.**
3. **A complete direct-line printing process, including white and green tinted papers, thin, medium and card-weight papers, black, red or brown line prints. BW Transparents and BW Film (intermediate prints) to supplement original valuable tracings.**
4. **A complete line of printing and developing machines to fit every requirement.**
5. **A continuing service . . . because Bruning sells everything for the engineer and draftsman, not just BW equipment. Buying a BW machine is, therefore, not a "one-time sale."**
6. **Continuing research and development in the customer's interest.**

Since 1897

CHARLES BRUNING COMPANY, INC.

NEW YORK	CHICAGO		LOS ANGELES
Atlanta	Boston	Detroit	Houston
Kansas City	Milwaukee	Newark	Pittsburgh
St. Louis	San Francisco	Seattle	

CHARLES BRUNING COMPANY, INC.
4726-28 Montrose Avenue, Chicago 41, Illinois

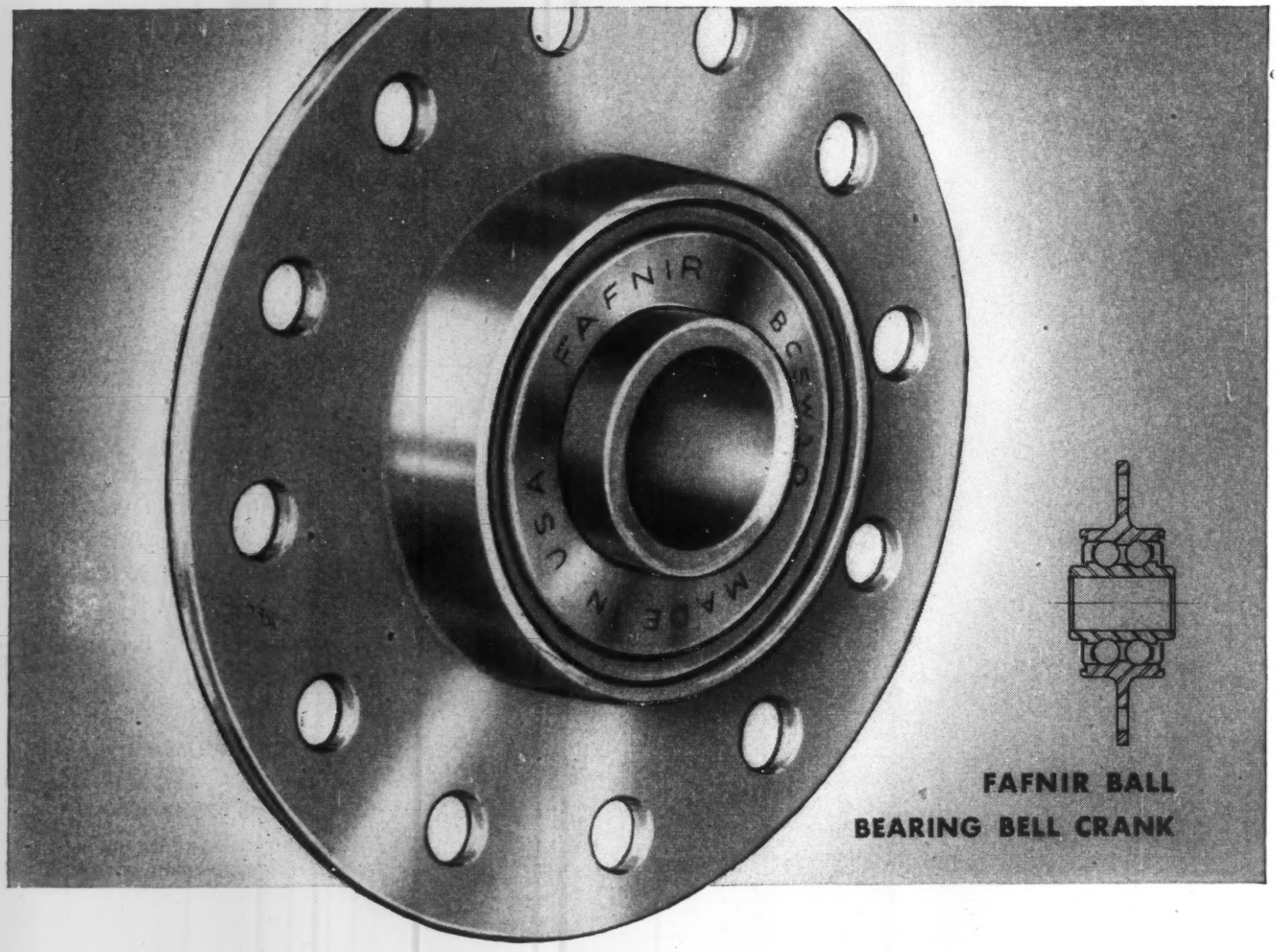
Gentlemen: I want to know more about Bruning BW Prints and equipment. Please send me information.

Name.....

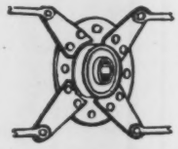
Company.....

Street.....

City.....*State*.....



A *ball bearing linkage for transmitting rotating, oscillating and reciprocating motion*



- **double-row ball bearings**
- **stainless steel shields or the new Fafnir PLYA-SEALS**
- **flange is tough, shock resisting analysis steel**
- **exposed surfaces cadmium plated**
- **two sizes of bore — .2500 and .3125 inches.**

FAFNIR designed this linkage unit for engine and flight controls in airplanes. Its simplicity, sturdiness, economy and ease of installation and maintenance have suggested a variety of applications to manufacturers of diverse machines and equipment requiring friction-free, positive linkage. Conveniently located flange holes permit attachment to Pitman arms and other mechanical connections to transmit rotary motion into reciprocating or oscillating motion, or vice versa. Flange is integral with the outer ring of this double row ball bearing, providing the rigidity needed to counteract side loads from angularly connected push-pull rods. Fafnir engineering services are available to you in developing the possibilities of this ball bearing linkage unit in your machines or equipment. Either send blue prints or write for data sheets on the Fafnir Ball Bearing Bell Crank. The Fafnir Bearing Company, New Britain, Conn.

FAFNIR BALL BEARINGS

MOST COMPLETE LINE IN AMERICA

Wichita City Library

New Precision in Textile Machine Design

The absolute size-uniformity of synthetic fibers invites higher speeds and greater precision of functioning in new types of production equipment.

Lighter machine parts and faster action is the order of the day. Gearing that was adequate in pre-war manufacture cannot measure up to the operating requirements of modern design, such as: gear trains of constant relative pitch-line speed, and critical limits in run out and backlash.

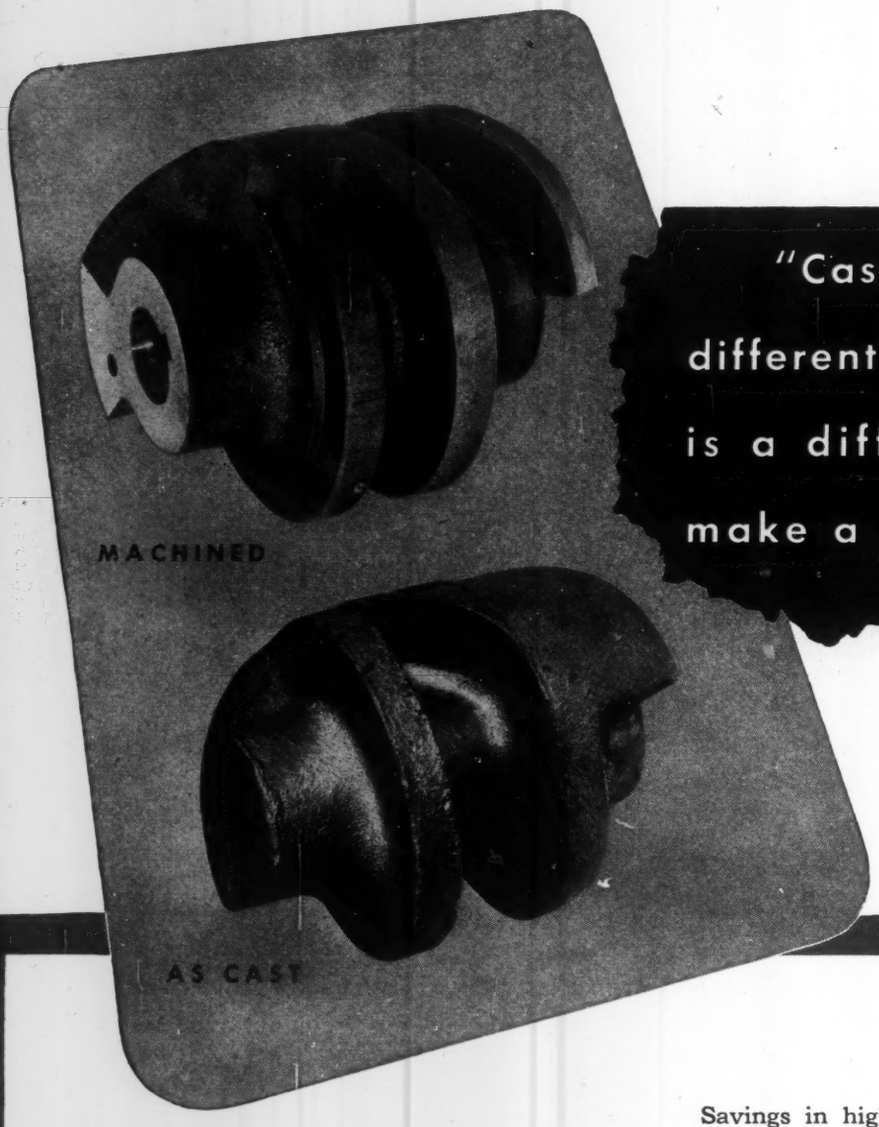
Precision gears have had to take over, and, for a growing category of uses, shaved gear accuracy is demanded. High speeds and quieter operation are everywhere in demand, necessitating higher gear quality for which the "Fellows Method" stands sponsor. Textile machine designers will find much of interest in our 64 page book "The Fellows Method". The Fellows Gear Shaper Company, Springfield, Vermont... or 616 Fisher Bldg., Detroit... or 640 West Town Office Bldg., Chicago.

FELLOWS SHAVED GEAR PRECISION IMPROVES MODERN TEXTILE MACHINE DESIGN

- ✓ **BY...** *ultra precise control of shaft and spindle speeds*
- ✓ **BY...** *capacity for higher operating speeds throughout*
- ✓ **BY...** *velvety smoothness and longer wear*
- ✓ **BY...** *vastly improved quiet...for the working comfort of mill operatives*

Fellows

THE FELLOWS METHOD...MACHINES AND TOOLS FOR ALL OPERATIONS FROM BLANK TO FINISHED GEAR



"Cast Steel is not a different material . . . it is a different way to make a steel product"

That is the statement of one of America's leading Research Metallurgists.

Take for example these 20-pound cams for an automatic machine.

Rough cast close to final shape and dimensions, they cost a great deal less to finish than if produced by other methods. And castings are free from directional properties!

Savings in high-cost machine finishing are of real importance to you. They help you meet competition with products you can afford to sell for lower prices, without sacrifice of quality, performance or long life.

The first step in building an improved product, or in cutting costs, is to plan it that way—a steel castings engineer can help you. Steel Founders' Society, 920 Midland Bldg., Cleveland 15, Ohio.

MODERNIZE AND IMPROVE YOUR PRODUCT WITH

STEEL CASTINGS

that's spindle RIGIDITY

The above close-up photograph of a Gray 50 H.P. Traveling Head Milling Machine was made while the machine was in actual operation. The carbide-tipped cutter is so steady and clear cut that you might think it was photographed standing still, instead of revolving at unusually high speed.

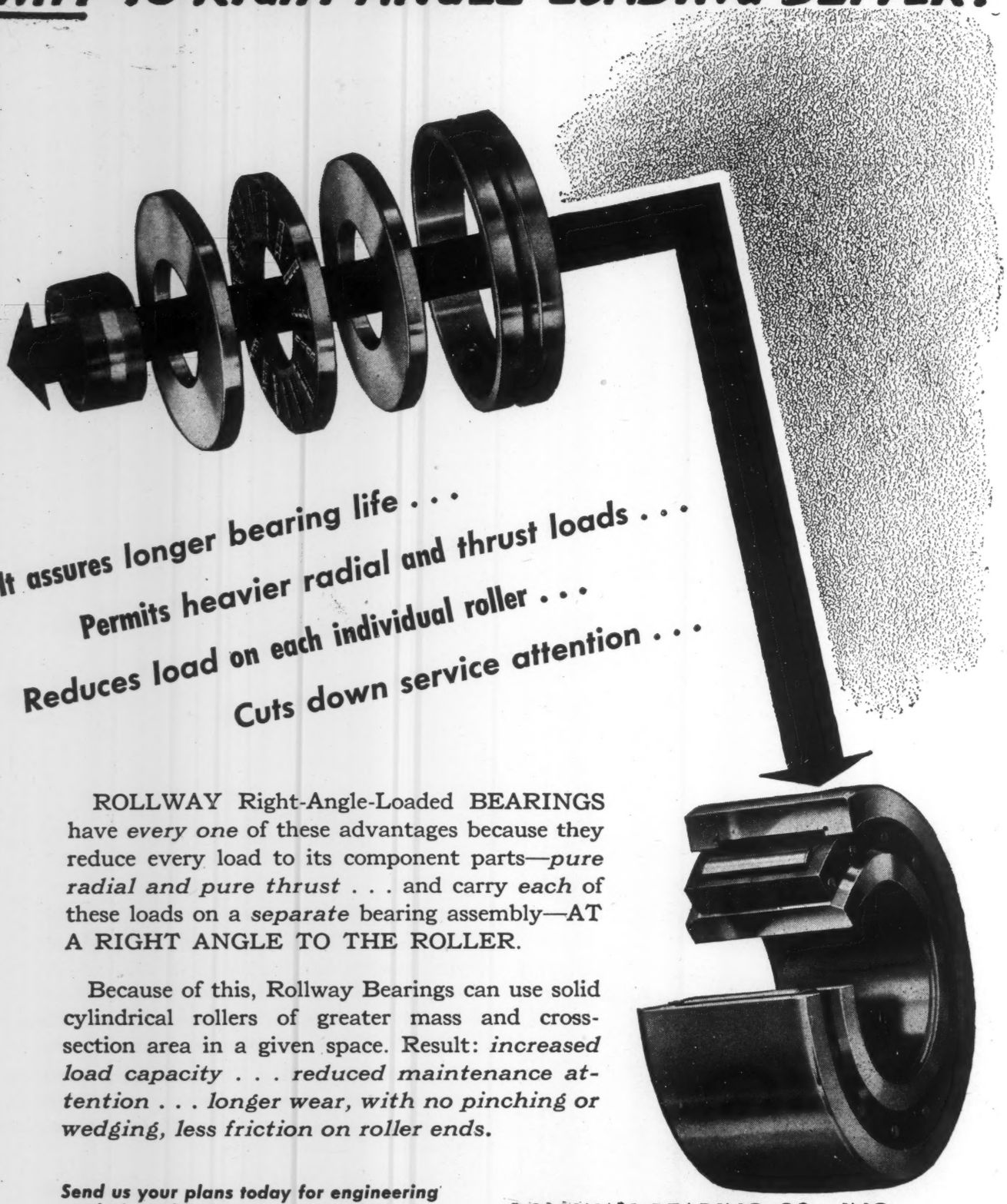
There is a reason — the spindle is mounted on Timken Tapered Roller Bearings, as also is the drive sleeve. High-speed negative angle milling of steel requires an unusually rigid, vibrationless spindle drive. Like other machine tool manufacturers, The G. A. Gray Company relies upon Timken Bearings for the ultimate in performance.

To be sure of getting Timken Bearing precision in your machines, look for the trade-mark "TIMKEN" on every bearing you use. The Timken Roller Bearing Company, Canton 6, Ohio.

Manufactured by G. A. Gray Company, Cincinnati, Ohio.

TIMKEN
TRADE-MARK REG. U. S. PAT. OFF.
TAPERED ROLLER BEARINGS

WHY IS RIGHT-ANGLE LOADING BETTER?



It assures longer bearing life . . .

Permits heavier radial and thrust loads . . .

Reduces load on each individual roller . . .

Cuts down service attention . . .

ROLLWAY Right-Angle-Loaded BEARINGS have *every one* of these advantages because they reduce every load to its component parts—*pure radial and pure thrust* . . . and carry *each* of these loads on a *separate* bearing assembly—AT A RIGHT ANGLE TO THE ROLLER.

Because of this, Rollway Bearings can use solid cylindrical rollers of greater mass and cross-section area in a given space. Result: *increased load capacity . . . reduced maintenance attention . . . longer wear, with no pinching or wedging, less friction on roller ends.*

Send us your plans today for engineering analysis and bearing recommendations.

ROLLWAY BEARING CO., INC.
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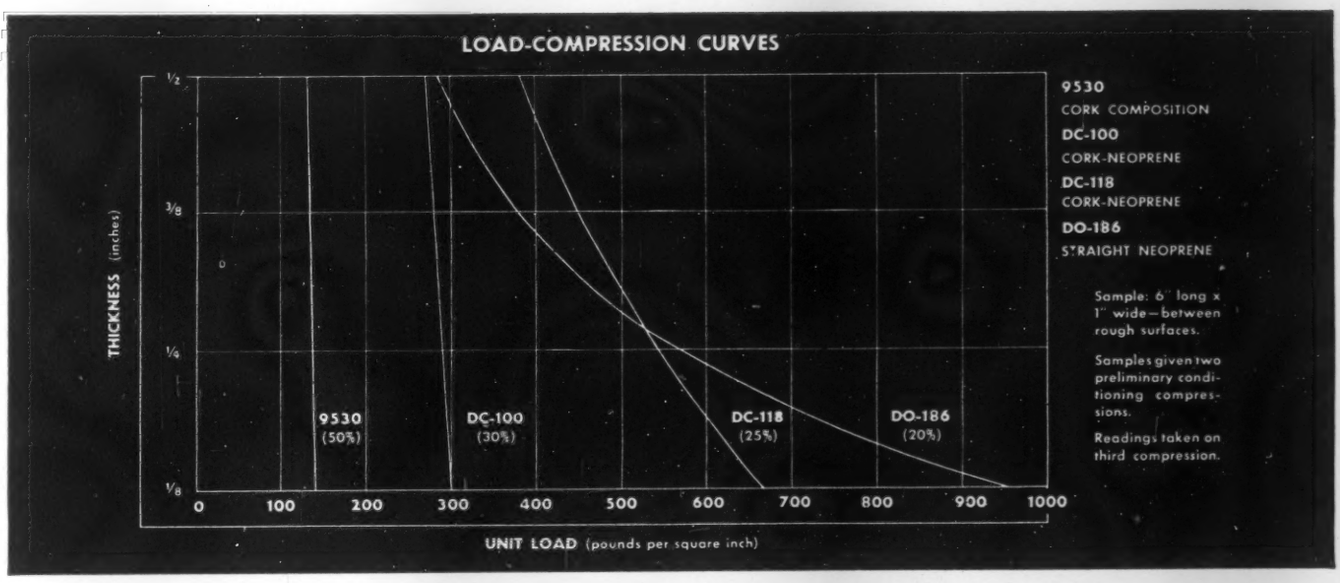
Rollway CYLINDRICAL ROLLER BEARINGS



RELATION OF GASKET THICKNESS TO LOAD

Type of sealing material determines effect of gasket thickness on compressive load

When gasket thickness is decreased, it may be necessary to increase unit load to maintain correct compression, assuming that width is constant. Whether a load increase is necessary and how much may be needed are determined by the type of sealing material used in the gasket.

The curves charted above show the effect on unit loading when the thickness of four different resilient gasket materials is varied. Each material is compressed the average amount recommended for it in normal service.

With a truly compressible material such as Armstrong's #9530 Cork Composition, unit load need not be increased to maintain constant compression. Gasket thickness can be reduced from ½" to ⅛", as shown by the chart, yet virtually the same load produces 50% compression.

A straight rubber gasket, on the other hand, requires a sharply increased unit load when its thickness is decreased. As with all non-compressible materials, its stress-strain curve varies with the ratio of the load area to the free area. The behavior of a typical material of this type is shown above in the curve for our DO-186, a straight Neoprene compound.

By combining cork and rubber in varying amounts, versatile compositions can be made that bridge the gap between cork and rubber. For example, Armstrong's DC-100 is a composition of Neoprene with a high cork content. Its behavior, therefore, approaches that of cork composition. A higher initial load is required to get adequate compression, but this load remains almost constant when gasket thickness is reduced. This is shown in the chart given above.

With DC-118, also charted above, gasket behavior will be more rubber-like because of its relatively low cork content. Here a substantial increase in load is required when gasket thickness is reduced from ½" to ⅛". Other Armstrong's cork-and-rubber compositions provide intermediate degrees of compressibility.

The chart given here illustrates why it is necessary to have ample bolting pressure when the thickness of a rubber or rubber-like gasket is reduced. Where adequate load is not readily available, one of Armstrong's cork-and-rubber compositions may offer a solution.

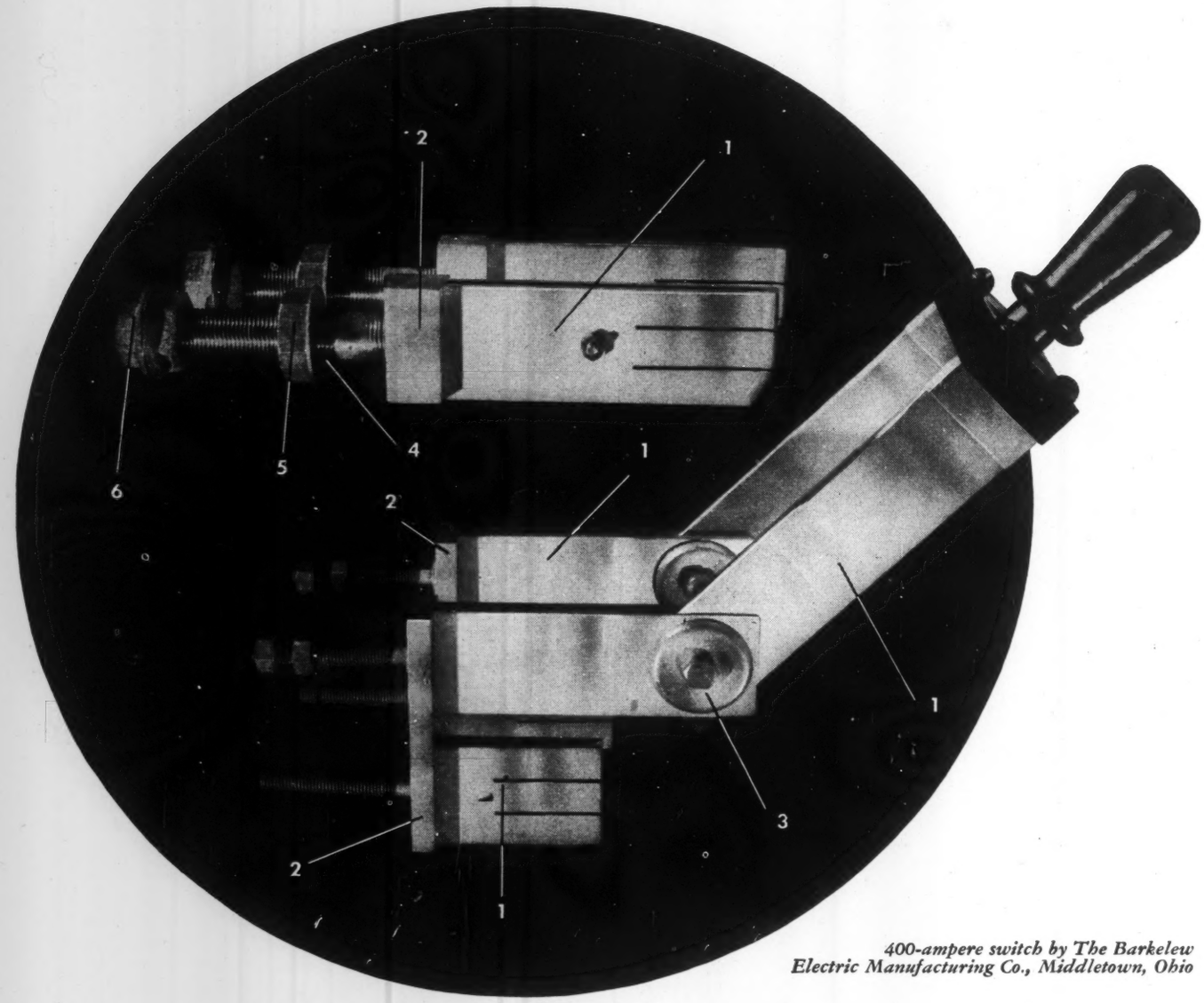
Since many variables influence the choice of a gasket material, we recommend that you discuss your specific application with an Armstrong representative before you set up your specification. He will be glad to suggest suitable materials and supply test samples.

If you prefer, send drawings and details to us. You will find our recommendations unbiased and keyed to good current gasketing practice.

SEND FOR FREE BOOKLET. For specification and application data on Armstrong's more than 50 resilient sealing materials, send for a free copy of the latest edition of "Gaskets, Packings, and Seals," twelve pages of helpful information. Address Armstrong Cork Company, Gaskets and Packings Department, 5101 Arch Street, Lancaster, Pennsylvania.

ARMSTRONG'S
GASKETS · SEALS · PACKINGS

Cork Compositions • Cork-and-Synthetic-Rubber Compositions
Synthetic Rubber Compounds • Cork-and-Rubber Compositions
Fiber Sheet Packings • Rag Felt Papers • Natural Cork



400-ampere switch by The Barkelew Electric Manufacturing Co., Middletown, Ohio

WIDE VARIETY OF REVERE METALS PERMITS EXACT SPECIFICATION TO MEET CONDITIONS OF USE

Note the number of different Revere Metals used by Barkelew in this switch, in order to assure low losses, reliability, accuracy, long life and economical manufacture.

1. *Electrolytic Copper.* For full conductivity.
2. *Free-Cutting Copper.* For quick, economical, trouble-free machining; in this case, producing sharp, clean, accurate slots and tapped holes in the copper base blocks. Free-cutting copper is rated in excess of 70% machinability of free-cutting brass, depending on type of operation.
3. *Herculoy.* Has the strength of mild steel, the corrosion-resistance of copper. The Herculoy washers in this switch assure permanence of pressure.
4. *Brass.* Washers, stamped out of sheet.
5. *Free-Cutting Brass.* Nuts, machined from free-cutting rod.
6. *Cast Electrolytic Copper.* For nuts not presenting machining problems.

Materials were very carefully chosen in designing this switch. For example, the hinge block for the high clip must have two slots milled in it to receive the clip leaves; Revere Free-Cutting Copper was selected for its superior machining characteristics. Slots in the lower hinge blocks are sawed all the way through, and here Revere Hard Drawn Electrolytic Copper is suitable.

Revere will gladly cooperate with you in working out the most advantageous application of metals to your products. Revere Metals are: Copper and Copper Alloys, Aluminum and Magnesium Alloys, Electric Welded Steel Tube.

REVERE

COPPER AND BRASS INCORPORATED

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FLEXIBLE COUPLINGS

Safeguard your direct-connected machines against unavoidable misalignment with the positive, resilient drive of Ajax Flexible Couplings.

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WESTFIELD, N. Y.

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GEARED POWER FOR INDUSTRY

THROUGHOUT America, in great and small production plants alike, wherever power turns the wheels of industry—Sterling Slo-Speed (Geared) Motors are leading the way to increased production records.

Sterling Slo-Speed (Modern Gear System) Motors give machinery manufacturers and production executives a complete power drive in one soundly engineered—compact—flexible—ultra efficient unit.

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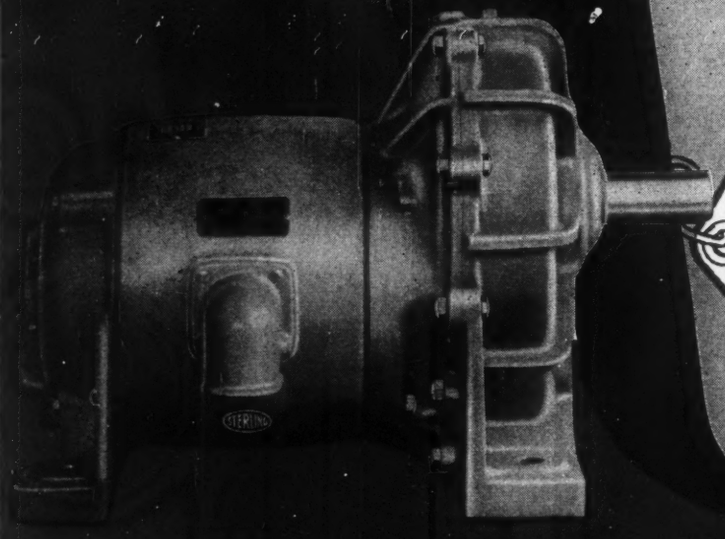


WRITE YOUR OWN TICKET

H.P.—From 1/2 to 15

GEAR RATIOS—From 3:1 to 50:1

STERLING ELECTRIC MOTORS

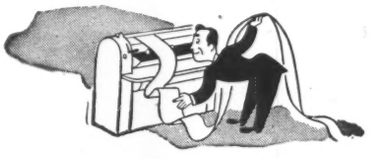
for Greater Perform-ability

NEW! THE OZALID STREAMLINER

• Reproduces your engineering and architectural drawings in seconds—also your typed, printed, photographic material.

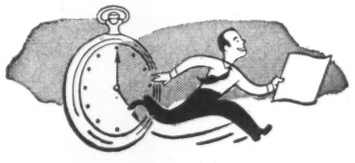
• Moderately priced . . . designed for the thousands of drafting rooms that want these 5 EXTRA VALUES in Printmaking at no extra cost—

1. EFFICIENCY! You always get positive (not negative) prints direct from your tracings . . . prints that are sharper, brighter, much easier for you to read, check, and make notations on.



You produce these without waste of material or waste of motion. Your tracings can be up to 42 inches wide, any length . . . and can be printed either on rolls of Ozalid sensitized paper or on cut sheets of matching size.

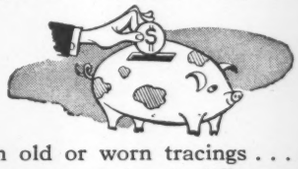
Your prints are always delivered dry, ready for immediate use . . . after just two simple operations—Exposure and Dry Development.



2. SPEED! ONLY 25 seconds to reproduce your standard-size tracings, specification and data sheets, etc.

3. ECONOMY! An 8½ x 11-inch reproduction costs you *one cent;* 11 x 17 inches, two cents . . . and so on. The Ozalid Streamliner soon pays for itself . . . in time, labor, and dollars saved.

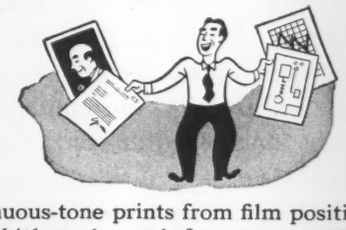
With it, you can also effect amazing short cuts in design. For example—eliminate redrafting when changing obsolete drawings . . . combine the details of separate tracings on *one* print . . . re-



claim old or worn tracings . . . make transparent overlays in different colors.

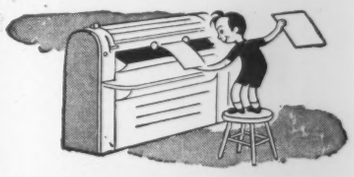
4. VERSATILITY! You can reproduce the lines and images of any original in black, blue, red, sepia, or yellow . . . on paper, cloth, foil, film, or plastic.

Simply use the Ozalid sensitized material you think best for job at hand; e.g., use identifying colors for prints of separate departments or operations . . . DRYPHOTO to produce beautiful con-



tinuous-tone prints from film positives (which can be made from any negative) . . . OZAPLASTIC to produce oilproof, waterproof prints for shop or field use. *All* prints are made in same fast, economical manner.

5. SIMPLICITY! NOW—printmaking is an easy desk job, automatic in practically every detail.



Anyone can feed originals and sensitized material into the Ozalid Streamliner. Prints are delivered on top, stacked in order—within easy reach of the operator, who does not have to leave her chair.

You can install your Streamliner anywhere; it requires only 11 square feet of floor space.

Write today for free, illustrated booklet . . . showing all the ways you can use the new OZALID STREAMLINER . . . and containing actual reproductions—like those you can make.

Gentlemen: DEPT. 202

Please send New Ozalid Streamliner booklet . . . containing reproductions of drawn, typed, printed, and photographic material. No obligation.

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Position_____

Company_____

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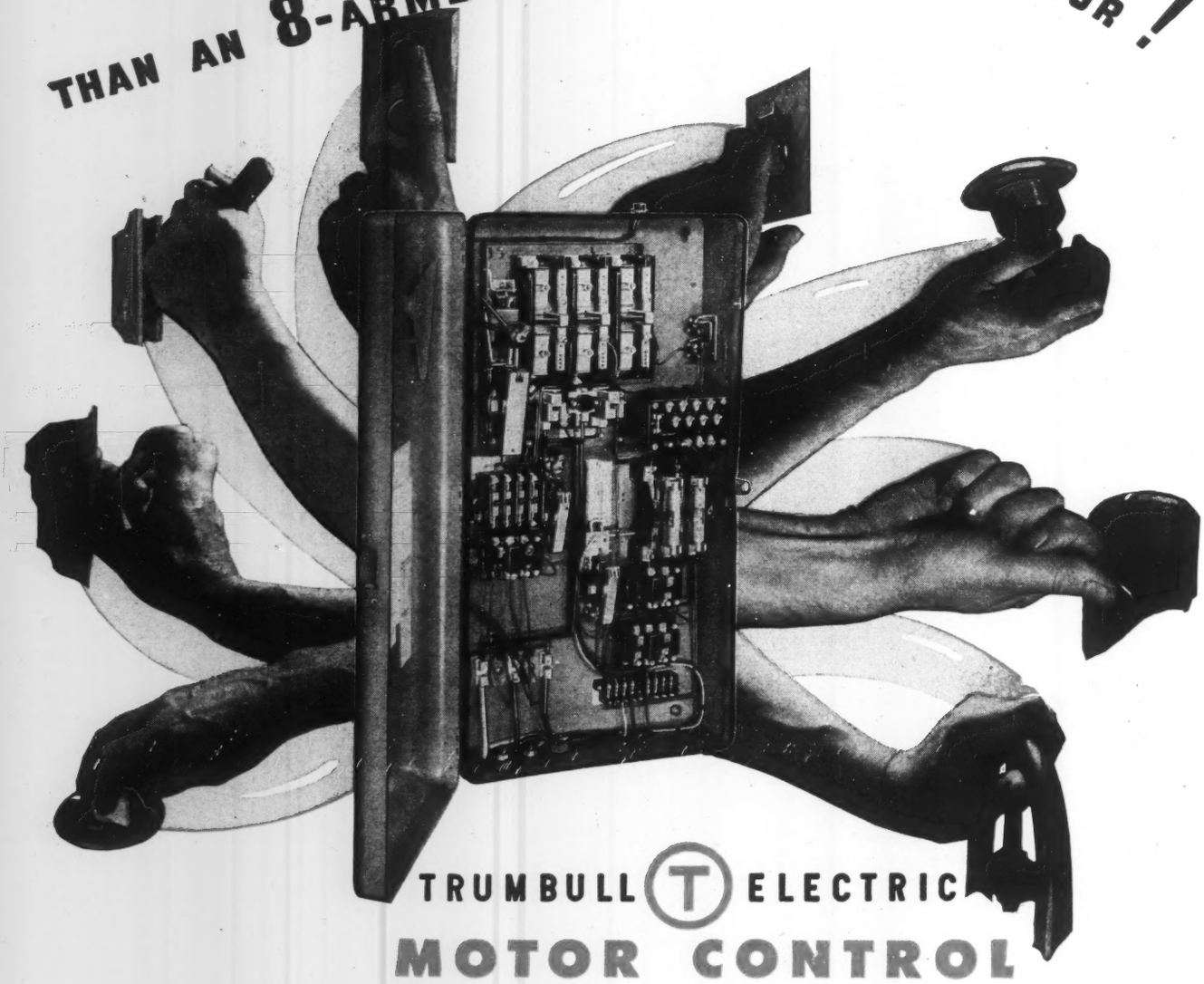

TRUMBULL (T) ELECTRIC MOTOR CONTROL

Click . . . click . . . click . . . click . . . all day long the sturdy magnetic contactors in this special Trumbull Control Panel cut the driving motors of a modern machine tool in and out . . . delivering thousands of finished pieces per hour where production was once counted in hundreds.

Nothing very unusual about a setup like this nowadays, but it's a good thing to keep this type of installation in mind because it has practically unlimited NEW applications and variations.

Trumbull engineers, who pioneered many aspects of efficient, modern, automatic motor control, are ready now to help NEW industries and NEW equipment builders in the drive to increase machine output as a means of reducing production costs.

THE TRUMBULL ELECTRIC MANUFACTURING COMPANY
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OTHER FACTORIES AT NORWOOD, OHIO • LOS ANGELES • SAN FRANCISCO • SEATTLE

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now is the right time to buy

because

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Furnaces are for immediate sale
Large selection now from which to choose

The War Assets Administration offers many types of surplus electric, gas and oil industrial furnaces—furnaces which should be on industry's production lines today. The offering includes models of well-known manufacturers covering uses such as:

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Heating furnaces
Metal melting furnaces
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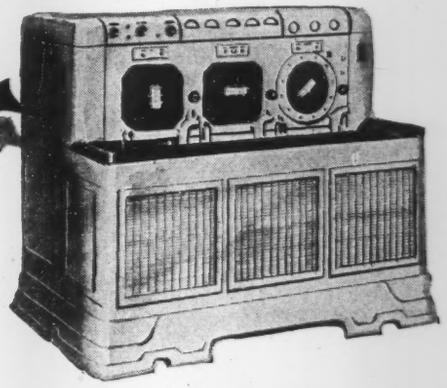

"TOCCO" INDUCTION HARDENER. Special Listing of W A B-47 Tocco units available at all Regional Offices.

To: WAR ASSETS ADMINISTRATION (Address nearest Regional Office)

We are interested in obtaining information on a furnace with the following specifications:

Use .....
Type .....
Size Working Space .....
Fuel .....Elec.....Gas.....Oil.....Max. Temp.....°F....
Other Equipment .....
.....
Name .....
Firm .....
Address .....
City .....State.....

Although this material has previously been offered to priority claimants, 10% of the merchandise has been reserved to fulfill any further needs of priority claimants including VETERANS OF WORLD WAR II, who are invited to contact the Regional Office serving their area.

This equipment is available for export. Any question on export control should be referred to Office of International Trade, Department of Commerce, Washington, D. C.

WAR ASSETS ADMINISTRATION

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how many sources = **a steady supply?**

Is **one** source enough to keep your production lines moving? Think it over. Then, when you count up your hydraulic pump requirements . . . **count us in!**

Gerotor hydraulic pumps are available in a range of oil capacities from .4 to 40 g.p.m., for **continuous** operating pressures up to 1200 p.s.i. All are precision engineered . . . famed for long life, uniform flow, high volumetric and mechanical efficiency.

Count us in . . . because you can **count on** Gerotor!

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hydraulic pumps
GEROTOR MAY CORPORATION
BALTIMORE 3, MARYLAND

SOUND DESIGN + VIBRATION CONTROL = SUPERIOR PRODUCT

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BONDED RUBBER
Shear Type
MOUNTINGS

Apply this simple formula to new products, particularly while in the blueprint stage, and watch its uncanny magic develop answers that bring a better product, lower manufacturing costs, and increased sales. Isolation of vibrational stresses frequently enables redesign for lighter weight, increases life of bearing surfaces, and protects vital parts.

Best of all, you will find the answer to your search for quicker and easier sales. Customers are enthusiastic when they find your usual high quality of performance coupled with new, *SMOOTHER* operation. Noise and vibration—the principal causes of industrial fatigue—no longer take their toll of efficiency and accuracy. Vibration Control cushions the nerves of industry.

For best results, bring your vibration problems to Vibration Control Headquarters. The service of LORD Vibration Engineers is yours for the asking. Write today for a vibration analysis of your new products.

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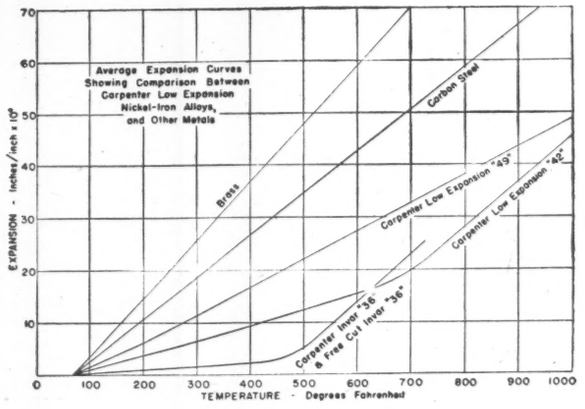
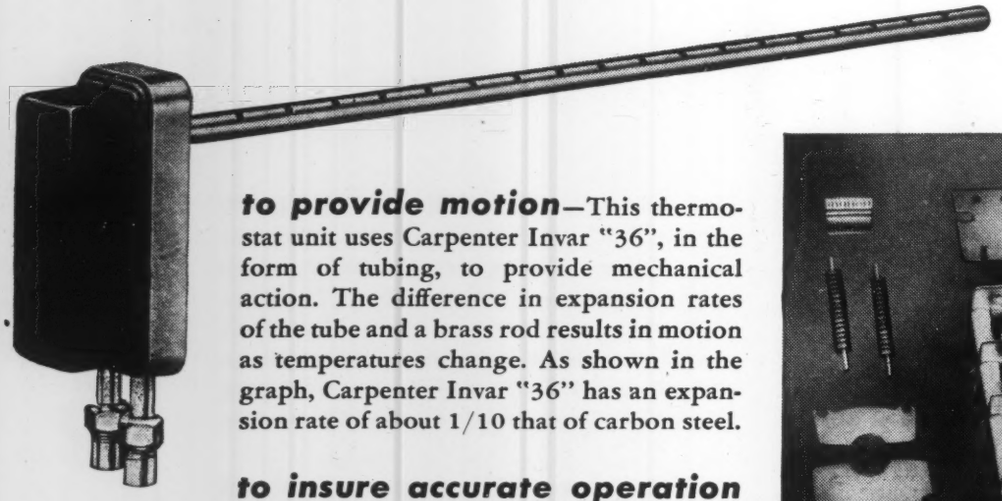
Every genuine Lord Mounting carries the name "LORD" embossed in the rubber or in raised letters on the forgings.

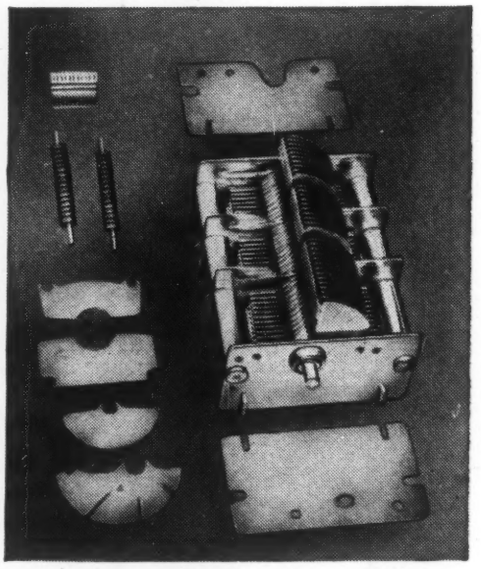
For MORE ACCURATE PERFORMANCE

CHECK THESE ALLOYS WITH LOW EXPANSION PROPERTIES





to provide motion—This thermostat unit uses Carpenter Invar "36", in the form of tubing, to provide mechanical action. The difference in expansion rates of the tube and a brass rod results in motion as temperatures change. As shown in the graph, Carpenter Invar "36" has an expansion rate of about 1/10 that of carbon steel.



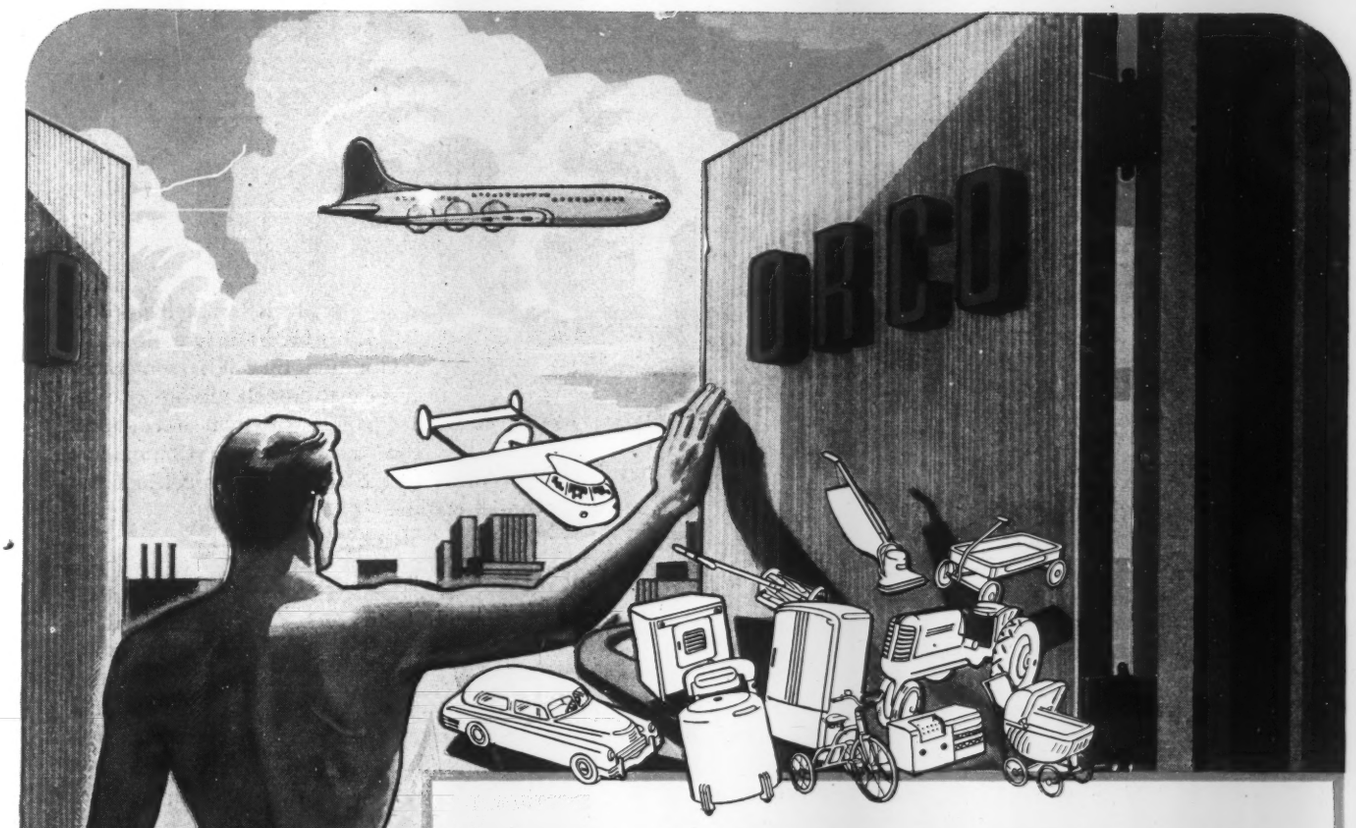
to insure accurate operation—Precision instruments such as condensers, regulators, electronic devices, etc., remain accurate through temperature ranges up to 400°F. This variable condenser is built almost entirely of Carpenter Invar "36". Shafts are of Carpenter Free-Cut Invar "36".

ENGINEERING INFORMATION on Carpenter Invar "36" and Carpenter Free-Cut Invar "36" is provided by a new booklet describing Carpenter High Nickel Alloys. The booklet includes the Carpenter "Map" of Iron-Nickel Alloy Characteristics and application data on each alloy. A note on your company letterhead, indicating your title, will start your Carpenter High Nickel Alloy Bulletin on its way.

The Carpenter Steel Company, 120 W. Bern Street, Reading, Pa.

Carpenter
High Nickel Alloys

- Temperature Compensator "30"
- Carpenter Invar "36"
- Carpenter Free-Cut Invar "36"
- Glass Sealing "42"
- High Permeability "49"



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● Extensive research and experimentation, accelerated by wartime necessity, introduced entirely new techniques in testing and evaluating rubber compounds for specific product development objectives.

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Topics

SURFACE ROUGHNESS measuring instrument has yet to be designed that can be produced in quantity, maintain its accuracy or calibration, and provide the same readings on any given surface. According to James A. Broadston, Chief Engineer of Surface Checking Gage Co., no generally acceptable criteria have ever been evolved that will truly correlate the performance of different machine finishes.

DENSITY of an atomic nucleus is so enormous that if it were possible to produce one cubic centimeter, the material would weigh 100,000,000 tons.

ENERGY RELEASED by complete fission of a pound of fissionable material is equivalent to that from burning 1500 tons of coal, according to Harry A. Winne, General Electric president.

TINY SELENIUM RECTIFIER has been used in place of rectifier filament tubes in portable radios, increasing operating life, withstanding rougher handling, requiring no warm-up period, and saving much space.

TO PUMP WATER from the Grand Coulee dam into the semiarid regions of south-central Washington, four 65,000 horsepower electric motors are being built by Westinghouse. Alternating-current motors, they will exceed by more than 50 per cent the capacity of the most powerful ac motor now in existence.

SO SATISFACTORY has been the utilization of German and Austrian scientists and technical experts brought to the United States recently, the War Department has decided to increase the number considerably. Plans are being made to release some of these Germans to private industry, research laboratories and educational institutions.

HIGH SPEEDS obtainable by a jet-engine plane allow the airplane to pass through "bumps" so quickly it is not disturbed. In fact there is so little vibration that it is sometimes necessary to attach vibrators to instrument panels so that instruments may be read, according to Commodore Frank Whittle of the Royal Air Force, inventor of the turbo-jet engine.

VOTE OF CONFIDENCE in the future of itself and the automobile industry has been expressed by the Packard Motor Car Co. in announcing a $20,000,000 program. This amount covers reconversion and plant expansion costs to date together with tools, dies and engineering for the company's new models and diversified products.

FUTURE DEMANDS for engineering graduates will be more than twice as great as before the war, according to Karl T. Compton, president of M.I.T. "Most of the war research concerned the *application* of science and any basic research was incidental to the major task. We must therefore promptly replenish the supply of the 'raw materials' of engineering and science."

NONMETALLIC MAGNET composed of hardened sintered combination of iron oxide and cobalt oxide is nonconducting. Known as Vectolite the material is extremely light and its nonconductive properties prevent electrical losses caused by current conduction.

DESPITE RECORD TONNAGES of steel, made during the war when production commonly exceeded 7,000,000 tons a month, the steel industry's monthly output from 1929 to 1945 averaged only 4,584,696 tons, according to a recent survey made by the American Iron and Steel Institute. The same tonnage could be made at 59 per cent operations under present capacity.

ELECTRONIC IGNITION for aircraft has been developed by the Bosch firm in Reichenbach, Germany. The system is expected to eliminate many of the shortcomings of magneto ignition. Utilizing a condenser and grid-controlled tube, the circuit is blocked after the discharge by the grid voltage, allowing the condenser charge to build up again.

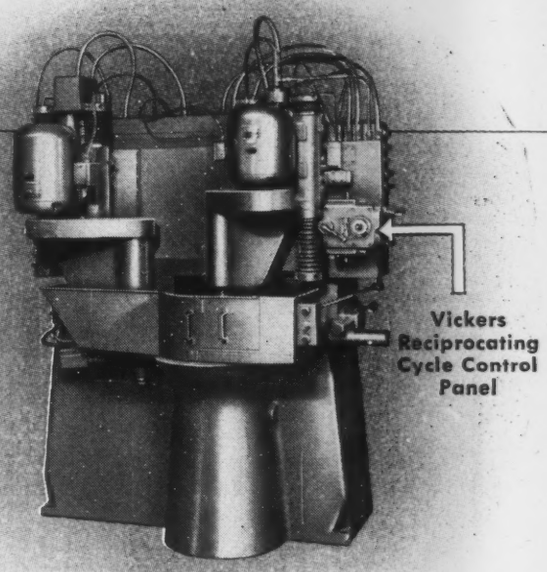
SPRINGFIELD MACHINE TOOL COMPANY

Uses

VICKERS
HYDRAULIC CONTROLS

to achieve

- INCREASED PRODUCTION
- BETTER WORK FINISH
- SIMPLICITY OF INSTALLATION
- VERSATILITY OF OPERATION
- PROTECTION OF MACHINE, WORK AND OPERATOR



Springfield Special Purpose Grinder

The manufacturer has utilized Vickers Hydraulic Controls on this special purpose grinder to provide an important increase in production, better work finish, simpler operation, and protection for the operator, machine and work.

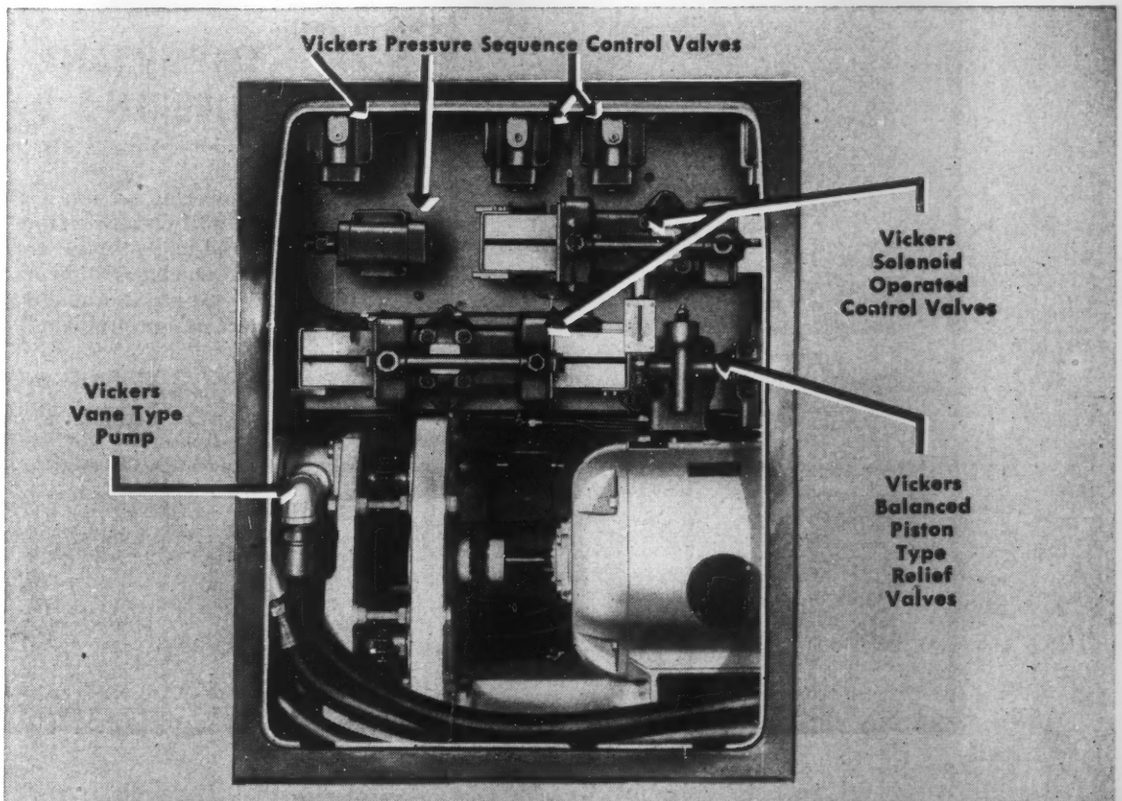
The machine grinds the backface and bore of the ring gear in one setup. Each grinding wheel is reciprocated hydraulically in proper sequence. All phases of machine cycle operation are interlocked hydraulically to prevent damage to work and machine.

Vickers Reciprocating Cycle Control Panel provides smooth reciprocation of grinding wheel, thus providing better finish. Stroke lengths are adjustable and maintained accurately thus eliminating unnecessary and time-consuming overtravel for a specific setup. Adjustable speed hydraulic drive of work spindle makes possible the best combination of speeds for better finish.

Other Vickers Gasket Mounted Valves (in panel type assembly shown below) permit low cost installation and greater accessibility for adjustment and maintenance. They centralize hydraulic equipment for space saving and improved appearance . . . piping is simplified.

A Vickers Application Engineer will be glad to discuss with you how hydraulic controls can be used to advantage on your products. Get in touch with nearest office listed below.

This is one of a series of applications pointing out the many advantages of Vickers Hydraulic Controls.



Rear View of Springfield Grinding Machine with Cover Plate Removed

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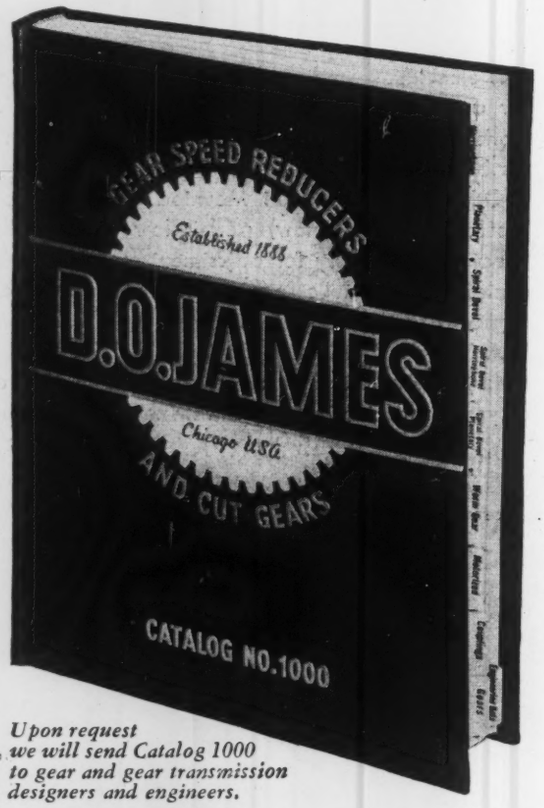

Upon request we will send Catalog 1000 to gear and gear transmission designers and engineers.

On the Engineering and Manufacture of Gears and Gear Reducers, Racks and Flexible Couplings

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Catalog 1000 contains 100 pages of invaluable engineering data. This engineering section has been compiled and obtained from various accredited sources and includes tables, charts and formulas that have proven useful and helpful in gear design problems.

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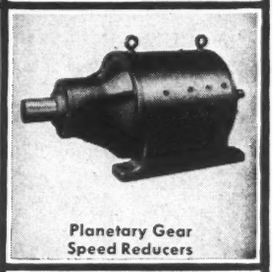
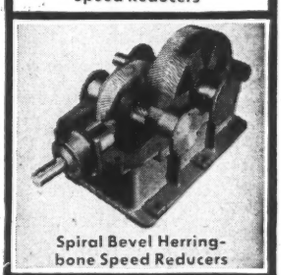
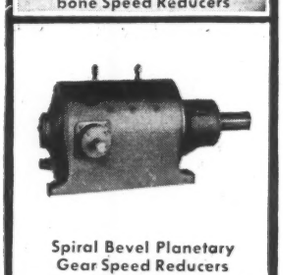
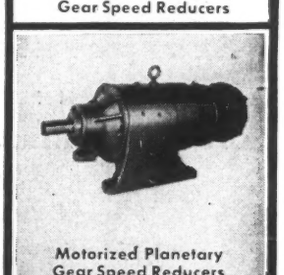
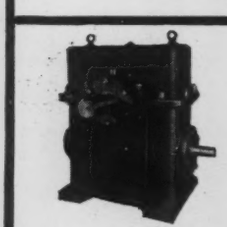

Planetary Gear Speed Reducers

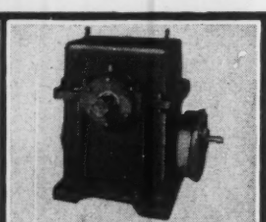
Spiral Bevel Gear Speed Reducers

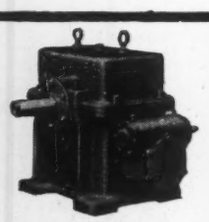

Spiral Bevel Herringbone Speed Reducers

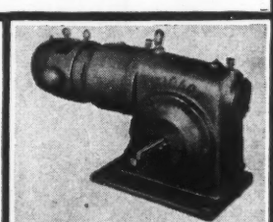

Spiral Bevel Planetary Gear Speed Reducers


Motorized Planetary Gear Speed Reducers


Type "H" Worm Gear Speed Reducers


Helical Worm Gear Speed Reducers


Double Worm Gear Speed Reducers


Motorized Worm Gear Speed Reducers

Motorized Helical Gear Speed Reducers

MACHINE DESIGN

Beam Deflections

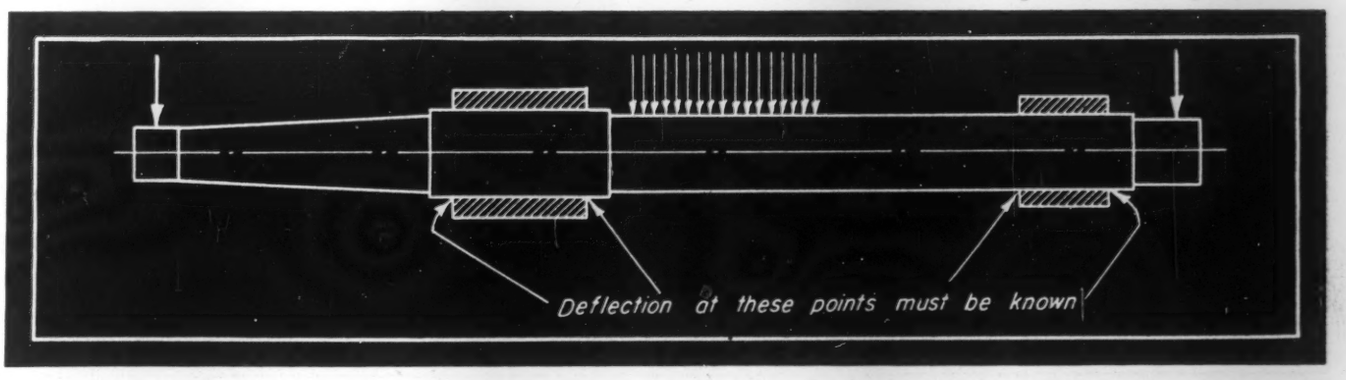
. . . by simple graphical analysis yield a visual appraisal which analytical formulas cannot express

By Walter Schroeder
Machine Designer, Research Dept.
The Cincinnati Milling Machine Co.

NECESSITY for predetermining beam deflections is reflected in the continuing interest in articles on the subject. A graphical method for obtaining beam deflections was developed about 80 years ago by Culmann and Mohr and although information about it may be found in some textbooks, the graphical method is not as well known among designers as its merit would deserve. While the method to be described here is applicable to any beam deflection problem, it is preferably used in those cases where loading is manifold and arranged at random, where beam cross section is not constant but varying, and where deflections at special points or over the full length of the beam are desired.

As an example, *Fig.* 1 shows a shaft having several steps in its diameter. Three loads are applied, one of which is distributed, and the shaft is mounted in two rigid plain

Fig. 1—Deflection of stepped shaft loaded as shown is of interest to avoid binding at the bearing ends

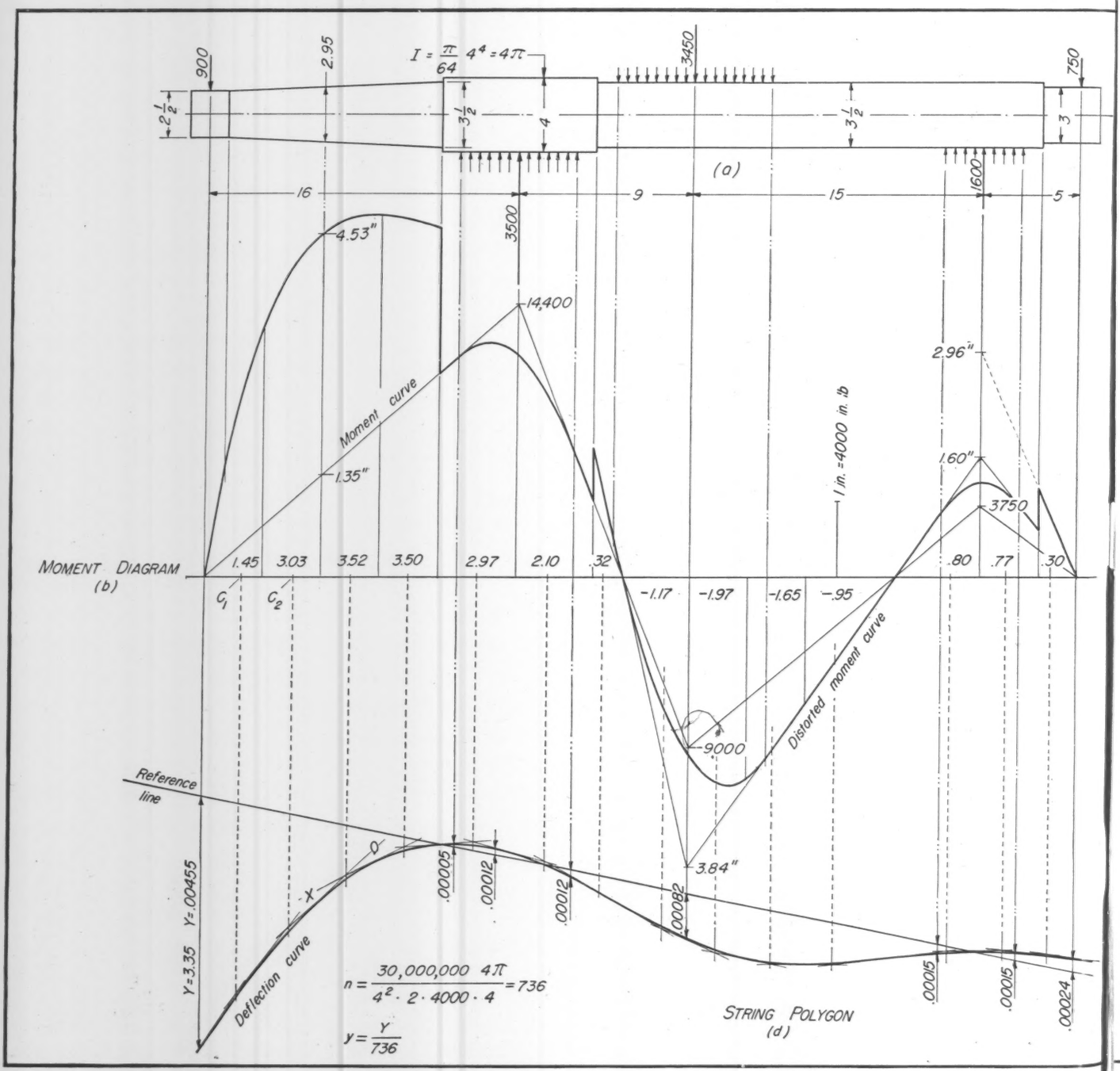


bearings. In this case the deflection of the shaft at the bearing ends is of interest since sufficient clearance must be provided to prevent binding at such points; or with a definite permissible maximum clearance the shaft diameters must be determined by the limited deflection. To find the amount of deflection within the length of the bearings the elastic line should be known at least for these distances.

Handbook formulas are of little value here, although the fundamental theory of beam deflection is valid. The difficulty lies with the analytical method of solving the differential equations, first for the slope, then for the deflection, and of establishing the constants of integration at each change of section. The graphical method avoids these difficulties and results in a curve—the elastic line—from which the deflections at any desired point may be scaled. These deflections appear in drastic magnification —many hundred times their true value—so that accuracy to three significant figures is easily obtainable. In common with graphical methods for other purposes there is the advantage that errors in drawing are less likely to happen than in calculation, but there is the disadvantage that each problem requires a new diagram and no general solution like a formula can be expected.

DIAGRAMS: Procedure for the preparation of diagrams is illustrated by the problem of *Fig.* 1. Although not essential for constructing the diagrams, but rather for completeness of the record, the beam should be shown on

Fig. 2—Beam layout and graphical beam deflection diagram analysis makes possible a complete visual appraisal



top, as in *Fig.* 2*a*, at a convenient scale and containing all necessary dimensions, loads, and reactions. The latter are calculated in the conventional way, which should offer no difficulty as long as only statically determinate beams are considered. As an example the left reaction is figured by taking moments around the right bearing center: 900(40/24) + 3450 (15/24) − 750 (5/24) = 3500 lb. Next, and vertically below *Fig.* 2*a*, the moment diagram *Fig.* 2*b* must be drawn. The moment curve shown is made by plotting the bending moments due to the external forces—i.e., loads and reactions—for every portion of

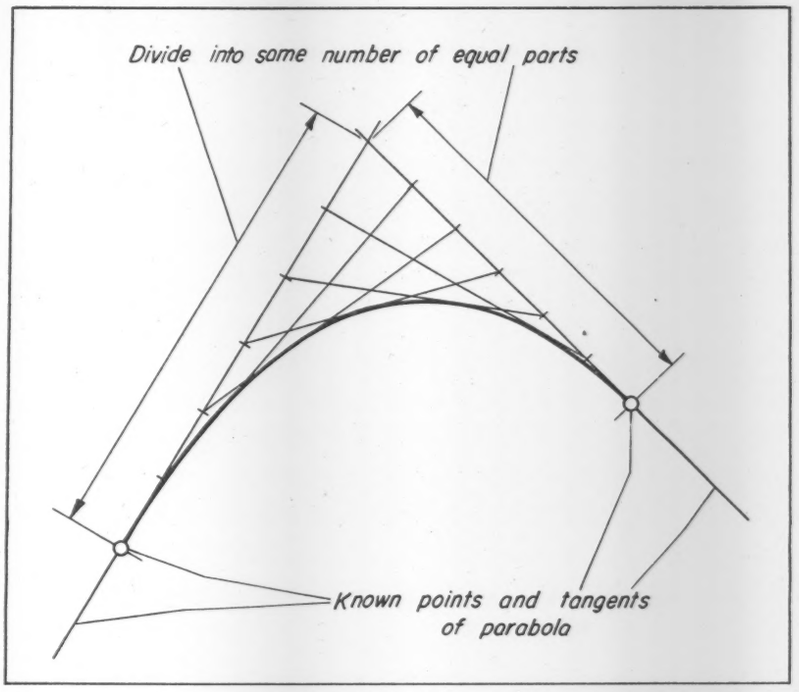
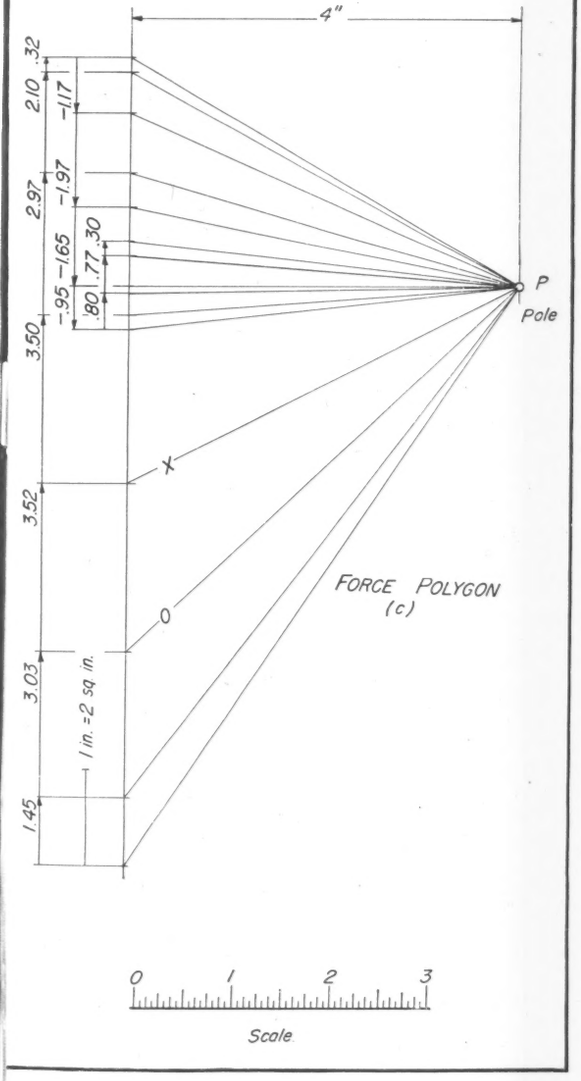


Fig. 3—Above—Graphical method for obtaining tangent parabolas



the whole beam. For concentrated forces the moments need only be figured at the load points and drawn to a suitable scale; connecting their end points by straight lines gives the moment curve. Moments that will bend the beam so that its center of curvature is below are plotted as positive and vice versa. For instance at the center of distributed load 3450 lb the bending moment is + 900 × 25 − 3500 × 9 = 9000 in.-lb. This is shown downward as 2.25 inches since 1-inch of the vertical scale represents 4000 in.-lb.

This straight-line moment curve is used only with beams of constant cross section carrying concentrated-loads. For variable-section beams the moment curve is distorted inversely to the variable moments of inertia (I). It is usually convenient to retain the curve for the section with the largest I (in this case the 4-inch diameter section) and to increase the bending moment for a section with I_1 in the ratio I/I_1. For stepped shafts this amounts to the ratio of diameters $(d/d_1)^4$.

On the left side the reduced diameter is gradually changing. This requires calculating the distorted moment curve point by point. For the value shown in the diagram the moment curve dimension is 1.35 and the corresponding shaft diameter 2.95. Thus the distorted moment curve must have the ordinate 1.35 $(4.00/2.95)^4$ = 4.53.

On the right-hand side where the reduced diameter sections are cylindrical, only three points need by calculated. At load 3450 lb the dimension 2.25 of the moment curve is increased to 2.25 $(4.0/3.5)^4$ = 3.84. At reaction 1600 lb the dimension 0.938 (for 3750 in.-lbs) is changed to 0.938 $(4.0/3.5)^4$ = 1.60 and to 0.938 $(4/3)^4$ = 2.96. Using these three values the distorted moment curve can be drawn with stranght lines as shown; the line to the 2.96 point for the 3-inch section is used only up to the shoulder.

Finally for the sections with equally distributed loads the straight-line moment curves are replaced by tangent parabolas obtained graphically as shown in *Fig.* 3. This results in the heavy line distorted moment curve.

Next the area under the curve is subdivided vertically and the area of each strip is measured in square inches—either geometrically or with a planimeter. The values obtained are written in their respective areas, as 1.45, 3.03, etc. For each strip of area the lateral location of the centroid should be marked as at c_1, c_2, etc. For triangles this is 1/3

of the height from the base, while for trapezoids a simple graphical location method is illustrated in *Fig.* 4.

Now the so-called "force polygon" can be constructed off to one side, *Fig.* 2*c*. It consists of a vertical line on which the areas of the moment diagram strips are represented as distances and drawn in proper sequence end to end. Positive areas are pointing upward, the negative ones downward. For example, the area 1.45 sq in. at the left of beam is shown as 0.725-inch since a 2-sq in. area is represented here as a 1-inch vertical length. All the marks separating the area distances on the vertical line are now connected to a pole *P* to the right. In the example *P* is 4 inches from the vertical line; its height has no influence on the result.

With the aid of this force polygon the string polygon, *Fig.* 2*d*, can now be constructed in the following simple manner. On the vertical projection line from each centroid in the moment diagram two lines are made to intersect; their directions are obtained from the force polygon and transferred parallel to those lines to the poles which are drawn through the ends of the respective vertical distances there. Thus for the third moment area of 3.52 sq in. the lines to the pole in the force polygon are marked *X* and *O* and the lines parallel to these are marked likewise in the string polygon. All these lines are tangents to the deflection curve which is easily drawn in now. It shows in an exaggerated way the shape which the shaft will assume under the influence of the bending moments. To measure the deflections a reference line is needed which in this case should be so drawn that the positive and negative deflections within each bearing (with respect to this line) are approximately equal. This is a feature of the graphical method which is difficult to obtain analytically when the deflection or slope at a certain point is assumed to be zero.

The actual deflection y at any point of the beam is equal to the scaled dimension Y in the diagram, divided by the scale factor n. This factor n contains the scale of the beam drawing (Figure 1*a*), the scale of the moment diagram (m in.-lb for one inch of ordinate), the scale of the force polygon (f sq in. for one-inch of vertical scale), the pole distance (p in inches), also the modulus of elasticity (E), and the moment of inertia (I) of the beam. Their relation is

$$n = \frac{EI}{a^2 fmp}$$

As shown on the drawing, *Fig.* 2, $n = 736$ and $y = Y/736$ for this example.

It should be emphasized at this point that the seemingly lengthy verbal description of the drawing procedure is no reflection of the work involved in preparing the diagram. Since a large portion of this work consists of repetitious drawing operations requiring no individual reasoning the actual performance is really fast. After becoming sufficiently acquainted with the simple technique the designer may also apply it in reverse, that is starting with a desired deflection curve he will find the moment diagram by drawing operations. After that force locations and beam sizes can be determined to satisfy the moment diagram. This graphical method has also been

Fig. 4—Below—Simple graphical method for locating the centroids of trapezoids encountered in diagrams

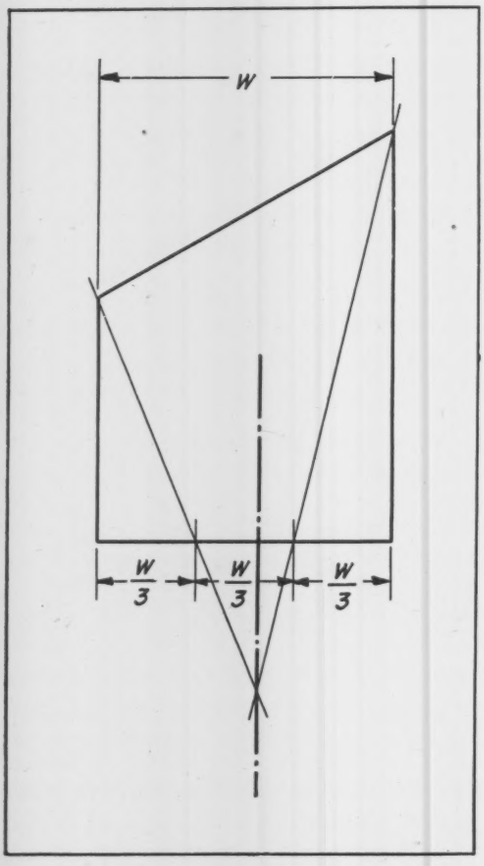
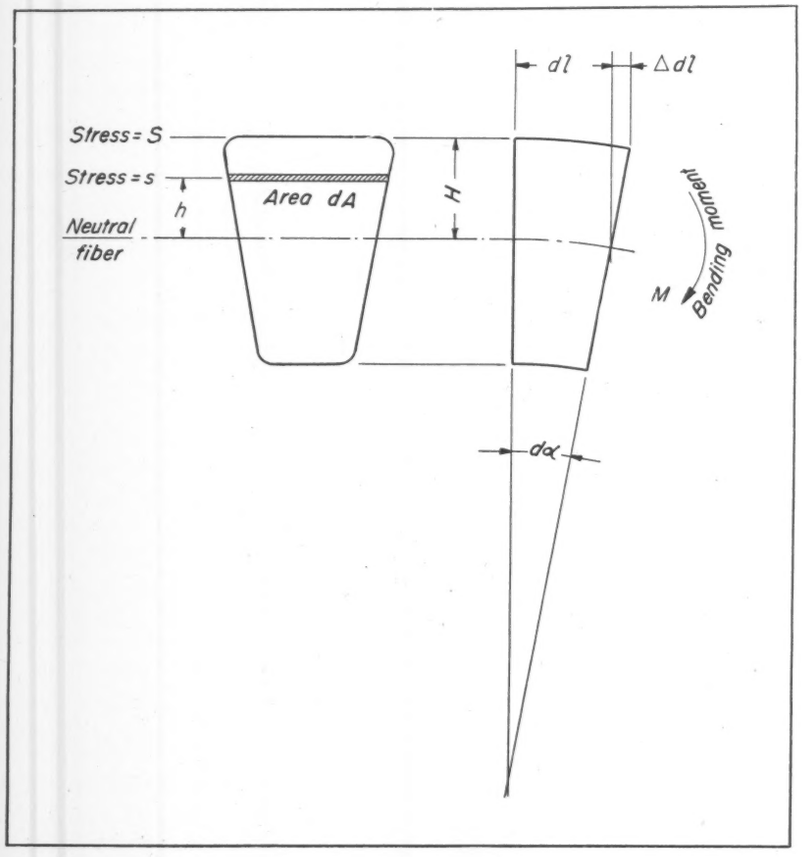


Fig. 5—Below—Basic relations of beam analysis where the beam element d l is deflected by bending



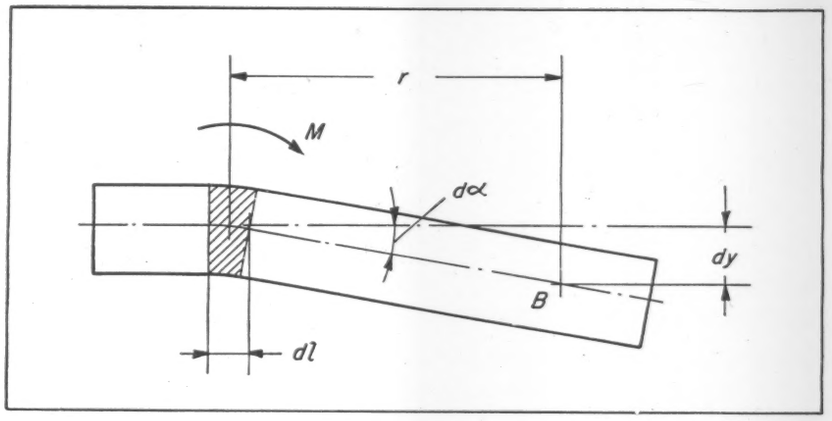


Fig. 6—Beam element dl shown as the only elastic portion of a beam in bending

Fig. 7—Below—Generalized moment curve over a beam

applied to solve statically indeterminate structures but in this article it will suffice to offer a concise proof of the basic method.

PROOF: Customary presentation in text books is by way of the similarity of the differential equations for both the deflection curve, as determined by analytical methods, and the funicular curve—as the curve of the string polygon is sometimes called. In the following, a simple and direct explanation is attempted. In common with the handbook formulas, only deflections caused by bending moments are considered; the effect of the shear forces is neglected here as can be done in most cases.

Basic Relations Derived

To derive the basic relations of beam analysis, *Fig.* 5 shows a beam element of length dl which is deflected by bending moment M causing the end surfaces (which are parallel when unstressed) to become inclined by angle $d\alpha$. For materials following Hooke's Law, i.e., where the normal stress is proportional to the change in length, $d\alpha$ is found thus: The stress at distance h from the neutral, unstressed fiber is proportional to h, or $s = kh$. This stress over area element dA equals force $dF = dA\ kh$ and this force in turn related to bending moment dM about the neutral fiber: $dM = dF\ h = k\ dA\ h^2$. The summation of all these dM is moment $M = k \int dA\, h^2$ which causes the deflection. The integral term is the familiar moment of inertia I for this cross section, thus $k = M/I$.

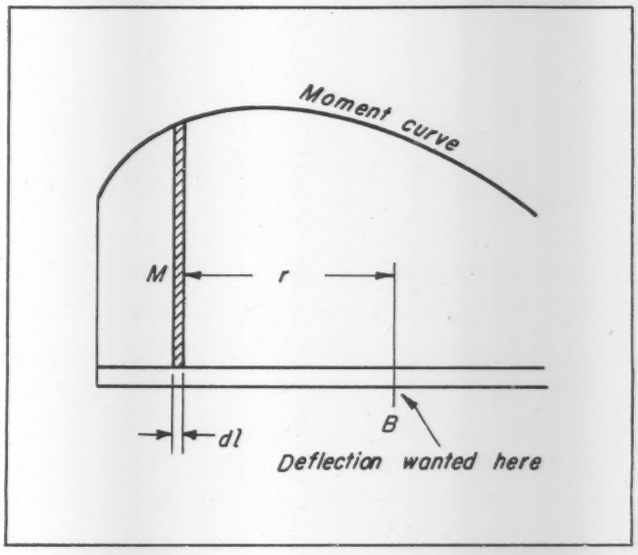
The outer fiber has lengthened by $\Delta\ dl = H\ d\alpha$ which must agree with Hooke's law $\Delta\ dl/dl = S/E$ where E is the modulus of elasticity. Combining now the various equations:

$$\Delta dl = \frac{S}{E} dl = \frac{kH}{E} dl = \frac{MH}{IE} dl = H\ d\alpha$$

or

$$d\alpha = \frac{M}{EI} dl \qquad \ldots\ldots (1)$$

This same beam element dl is shown in *Fig.* 6 as the only elastic portion of a beam. When dl is deflected by M, the outer, rigid part of the beam sags by angle $d\alpha$. Point B at distance r from dl sags $dy = r\,d\alpha = Mr/EI$ dl. Since a real beam is wholly elastic we have



$$y = \int \frac{Mr}{EI} dl \qquad \ldots\ldots (2)$$

This equation giving the deflection at a definite point is also very useful for analytical work, here it is solved graphically. In the foregoing example, the bending moments were shown as a curve in the moment diagram. In *Fig.* 7 a generalized moment curve is shown over the beam, moment M is shown at distance r from B where the deflection is wanted. The term $M\ dl$ from Equation 2 is shown as the narrow, cross-hatched area. It is obvious that the summation of all areas $M\ dl$ times distances r as required by Equation 2 can be done as well by adding the products of wide areas A_1, A_2, A_3 and centroid distances L_1, L_2, L_3 respectively as shown in *Fig.* 8. Deflection at B thus consists of $\Delta y_1 + \Delta y_2 + \Delta y_3$ where $\Delta y_1 = A_1\ L_1/EI$ etc. This latter equation is solved by the force polygon in *Fig.* 8. By inspection of the similar crosshatched triangles the proportion $\Delta y_1 : L_1 = A_1 : EI$ can be stated at once which gives the required relation of the involved factors. Had point B been chosen at 2 deflection y would be expressed by $\Delta y_1 + \Delta y_2$; if B were at 4, it would take four items Δy to make up y. The string polygon thus gives the exact deflections at the separation lines of areas A and, therefore, the deflection curve is defined by these points and the tangents as transferred from the

force polygon. While the deflections are originally obtained as measured from a tangent on the beam in *O*, the elastic line as such is fully described by the bending moment curve regardless of the supporting conditions; the deflections may be scaled from any desired reference line. In *Fig.* 8 deflections y_T apply to a cantilever beam fixed at *O* and deflections y_R to a beam resting at *O* and 5 having the identical dimensions and moment curve. The direction of the reference line depends on the height selected for pole *P*. It rarely turns out to be horizontal, still the deflections measured vertically are correct.

VARYING BEAM SECTION: The treatment applied to the changing beam sections of the example in *Fig.* 2 is easily proved now. With *I* denoting the largest moment of inertia and I_1, I_2 etc., smaller moments of inertia of the same beam, the deflection of any specific point due to the elasticity of beam section with I_1 is according to Equation 2

$$y = \int \frac{Mr}{EI_1} dl$$

integrated over the length of section I_1. If this equation is written in the form

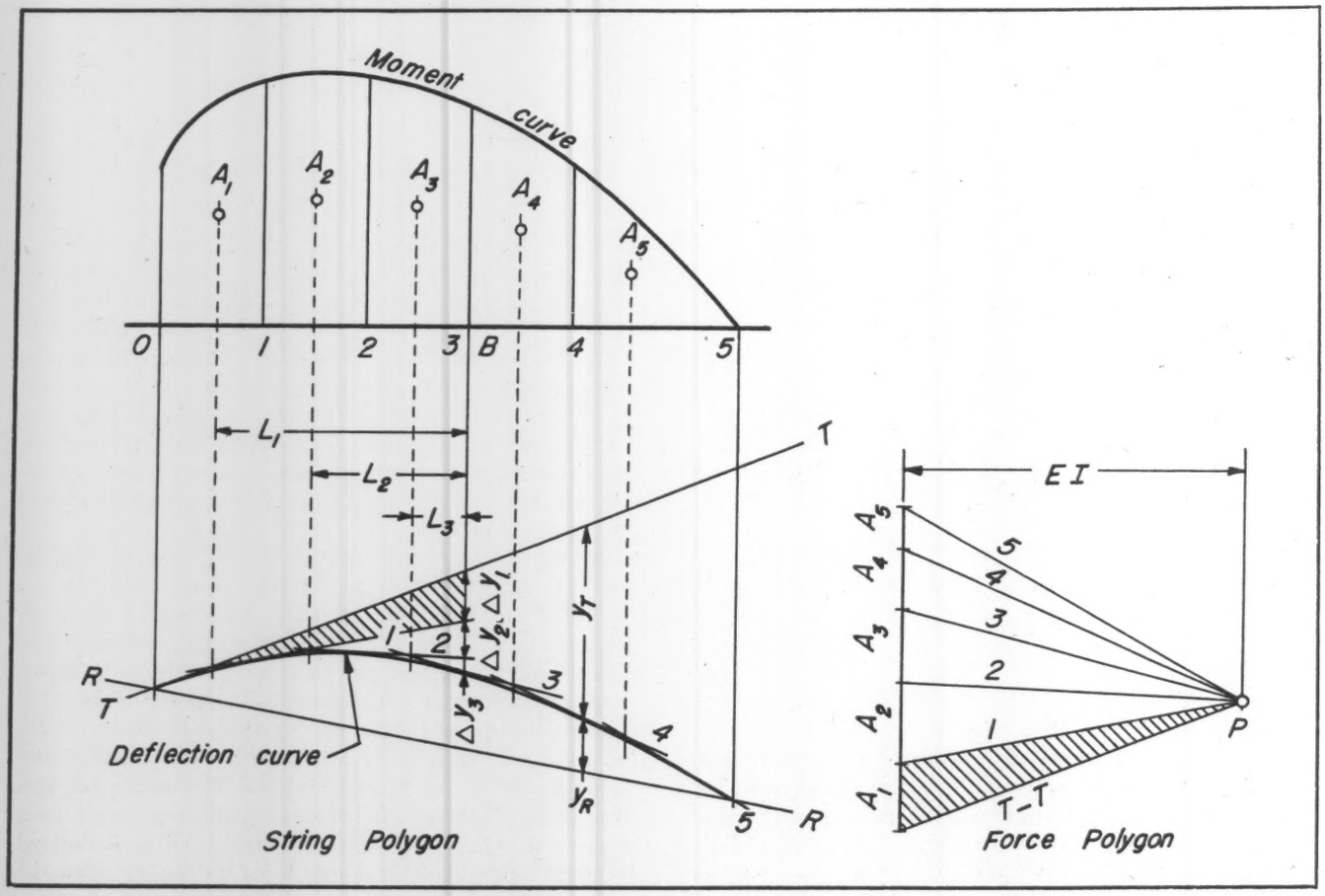
$$y = \int \frac{M(I/I)r}{EI} dl$$

it is evident that the moments *M* shown in the moment curve must be modified by ratio I/I_1 so that in the further work only the value *I* need be dealt with.

SCALE FACTOR: The graphical method would be of no practical value if the diagrams had to be drawn so as to yield only full scale deflections because these are generally too small to be scaled conveniently. As pointed out previously the deflections are obtained at very large scale and in conclusion the scale factor *n* should be derived. If the terms *A* and *EI* as represented by distances in the force polygon were both drawn to the same scale the deflection curve would appear at the scale $(1/a)$ of the beam drawing. Using the abbreviations already introduced, in the force polygon 1-inch vertically actually stands for *f* sq in. of moment area, hence stands for ($f \times m$ in-lb $\times$ *a* in.) moment area. Horizontally *EI* is represented by *p* inches so 1-inch = EI/p lb $\times$ in^2. The ratio of these two scales is $EI/p\ f\ m\ a$ by which the drawing scale $(1/a)$ has to be multiplied; thus $n = EI/a^2\ f\ m\ p$ as already stated in connection with the example.

SUMMARY: The graphical method of finding beam deflections thus is shown to be a simple procedure to solve the analytically correct integral of Equation 2 by drawing operations which give the correct answer, not an approximation. No painstaking exactness is required in the drawing work and still a remarkable accuracy is obtained — partly due to the extreme magnification for the deflection curve in the diagram. The method described affords a visual appraisal of the effect of load application and change of beam section which analytical formulas cannot express and should prove a reliable aid in the designer's work.

Fig. 8—Deflection diagrams for identical beams, y_t cantilever fixed at 0 and y_r resting at points 0 and 5

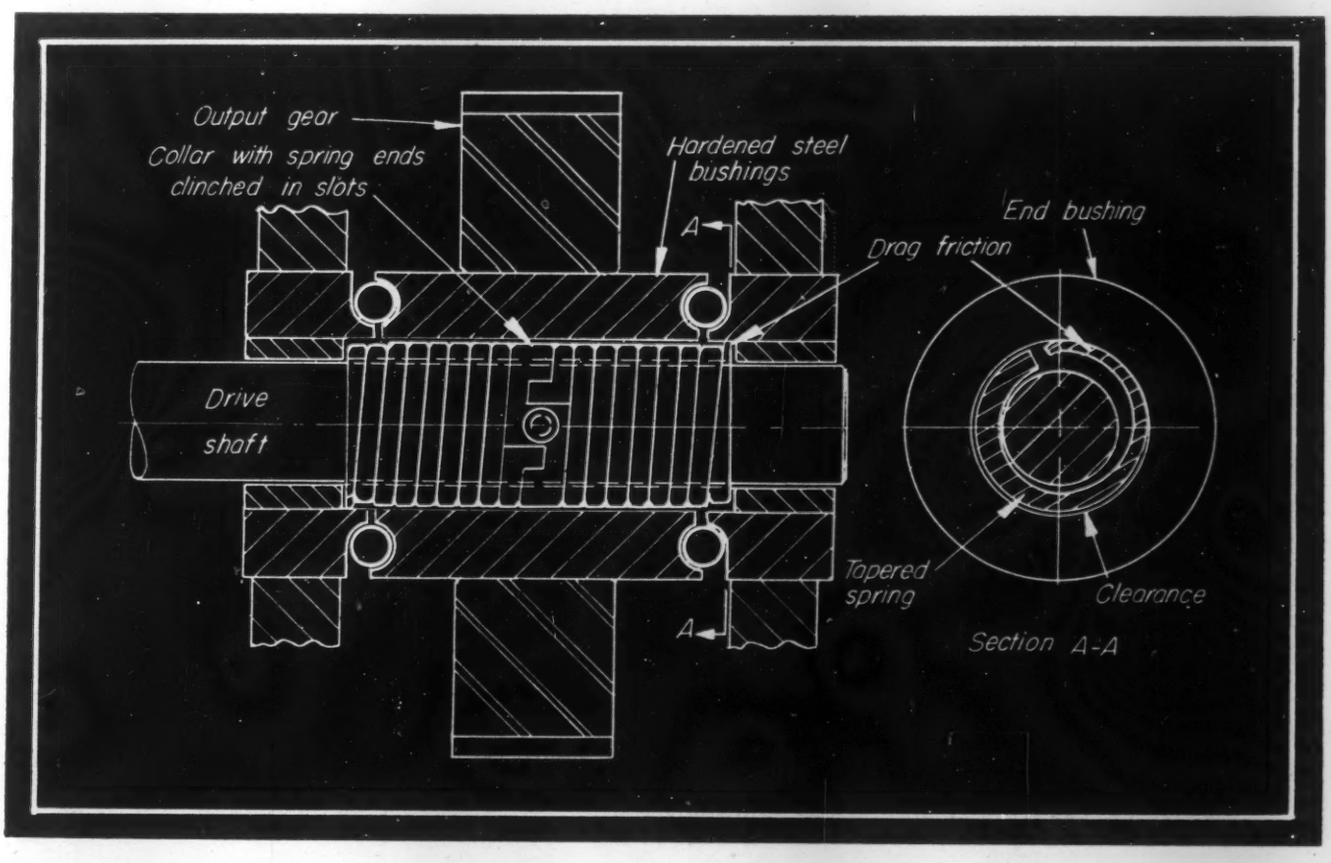


Scanning THE FIELD for Ideas

TWO-WAY spring clutch, capable of driving in each direction and overrunning in both directions, is illustrated schematically in the sectional drawing, below. Shown as part of a gear drive, the automatic clutch allows the driven element to overrun the drive in the same direction as long as the drive is running and in either direction when the drive shaft is stopped.

This clutch was designed to permit dual operation of reversing drives without the need for shifting a clutch or a differential. For instance, a hand crank or a power drive may be used independently without the power drive spinning the crank or the crank dragging the power unit. Developed and patented by Williard E. Smith Jr., Worcester, Mass., the clutch is of the expanding spring type used widely by the Ordnance Dept., Navy, Air Corps, and others in various applications and in sizes from a few pound-inches to thousands of pound-feet torque capacity.

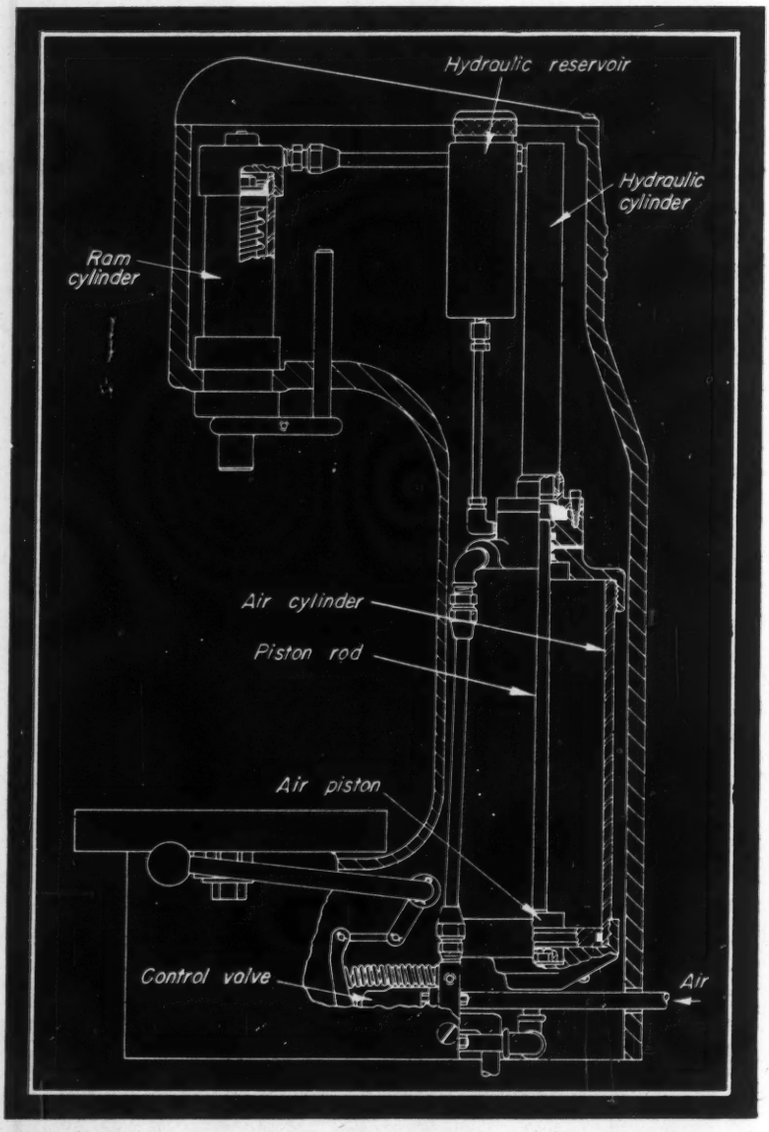
Operation is independent of speed and clutching takes place at any angle. Referring to the drawing, drive shaft has a pinned collar, centrally located in the clutch between two spring elements. End of each spring is clinched in slots in the collar so that when the drive shaft rotates in either direction that spring which tends to unwind engages the hardened steel bushing on the driven member. To assure that the spring will have sufficient drag to start unwinding, the free end extends into the stationary raceway in the housing. This end of the



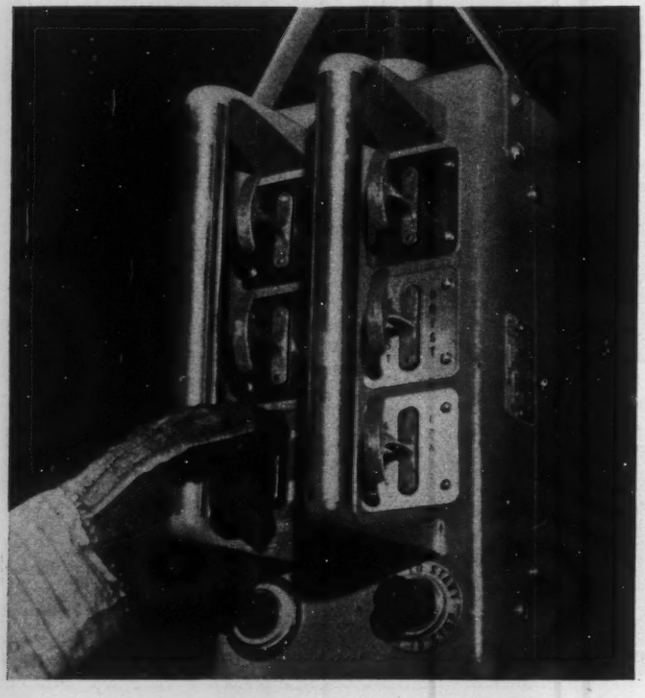
right-hand spring is shown in section. At this position the spring is relieved for clearance with the extreme end bent up to produce sufficient drag needed to start engagement. Once engagement is initiated this drag has no further function because the drive through the spring and bushing tends to increase engagement with increasing load, thereby driving the load up to the breaking point of clutch.

Any tendency of the gear to overrun drive shaft pulls the spring ahead, relieving unwinding pressure and allowing free wheeling action. Before being capable of overrunning backward, however, the clutch must overrun foreward after being driven, or the driving element must run backward slightly.

If one spring element only were used in a clutch assembly, a one-way drive with two-way overrun would be obtained.



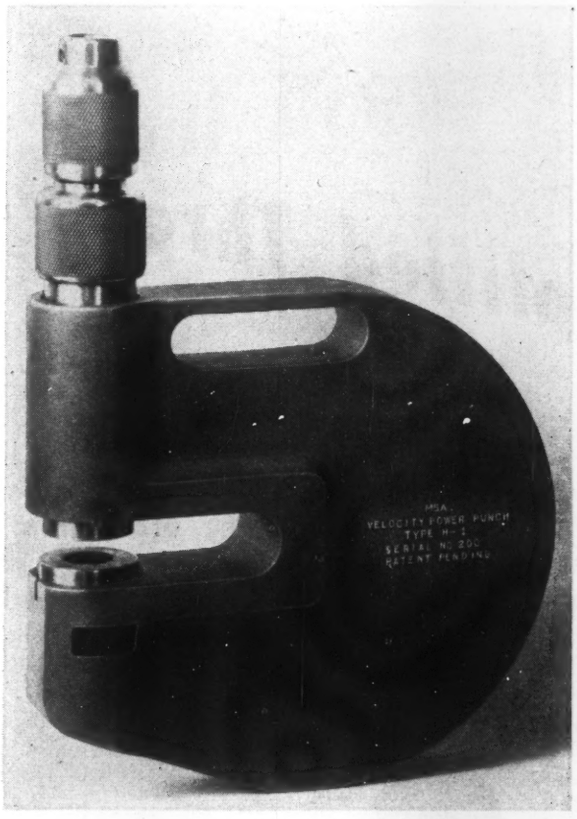
Air-hydraulic system utilized in the press shown in sectional view at right, provides features of a hydraulic press, giving a 50 to 1 pressure multiplication of air pressure. In this system designed by Air-Hydraulics Inc., air is piped through the operating valve in the base to the air cylinder, forcing the piston rod up into the hydraulic cylinder. The displaced oil passes into the ram assembly to produce a ram pressure of 50 pounds for each pound per square inch of air inlet pressure. The ram remains in depressed position until the control valve is released, returning the ram to its original position by a 200-pound return spring. This also returns the air cylinder to its starting position by movement of the oil into the hydraulic cylinder. A hydraulic reservoir keeps the system filled through a chamber at the bottom of the cylinder.



Pendant control left, has pull stations instead of conventional pushbuttons, giving time-delay acceleration for crane motors. A General Electric system, it provides five-point speed control. Because time-delay acceleration is provided in the pendant station, accelerating relays usually used on magnetic control panels are obviated, reducing the size

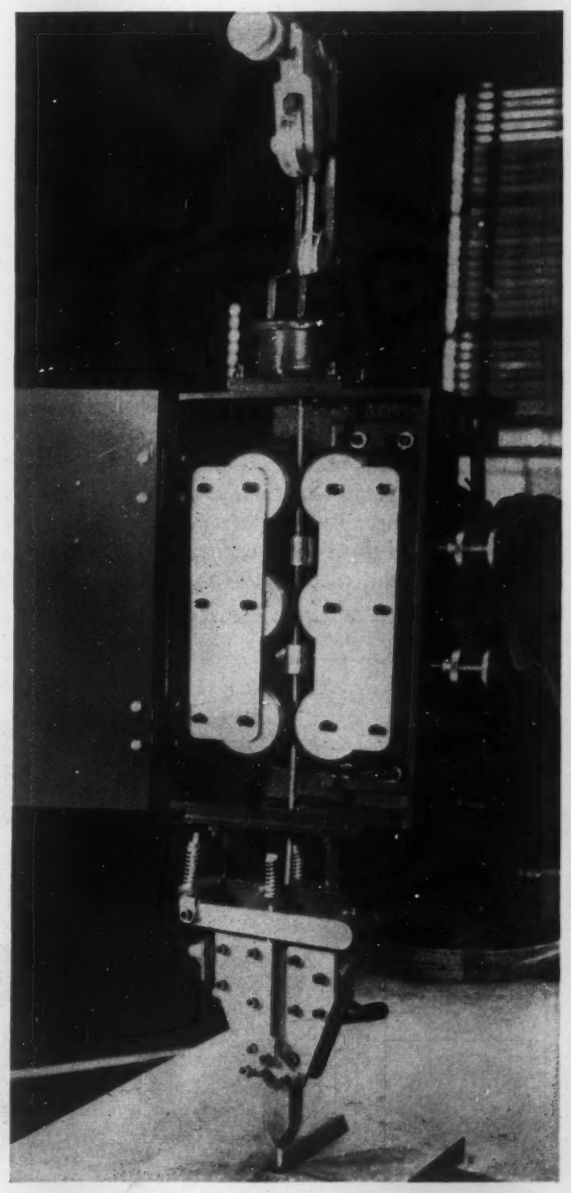
of the control panel. Station has one handle for each direction of crane motion. As the handle is pulled out, its corresponding motor accelerates to the speed indicated by the position of the handle in the operator's fingers. Emergency button at the bottom cuts off power from all motors. A reset button prevents false operation after overload or undervoltage conditions. Although some experience is required on the part of the operator, he has "feel" of control while manipulating the hoist.

Portable power punch, illustrated below, utilizes the explosive charge of a cartridge for its operation. With the unit in position, a light tap on the head detonates the cartridge, punching the hole. Developed by Mine



Safety Appliance Co., this device is especially useful for punching relatively heavy sheet stock in remote locations or in positions too confined for conventional power tools.

Grid construction, for holding flux coating to the core of welding electrode wire, allows the electrode to undergo flexing and bending while unwinding from a wheel without breaking away of the flux. Developed by Arthur Barnard, research engineer of the National Cylinder Gas Co., the metallic grid extends to the periphery as shown in the sketch, below, providing for conduction of the welding current through the flux coating to the steel core. Fin-ridged construction of the core further provides for conducting unusually high welding currents. This particular design causes electrode and base metal to melt at a high rate, permitting high welding speeds and welding economies. In the welding head adaptor, below, the coiled wire is fed through straightening rolls, feeding mechanism and contact jaws. This development provides for feeding a coated electrode into the arc from a reel, in the same manner as bare electrode automatic welding.



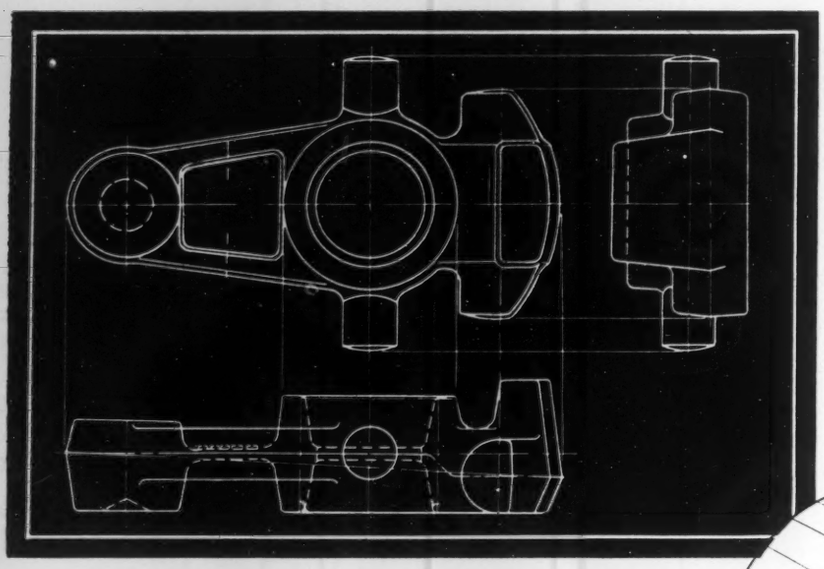
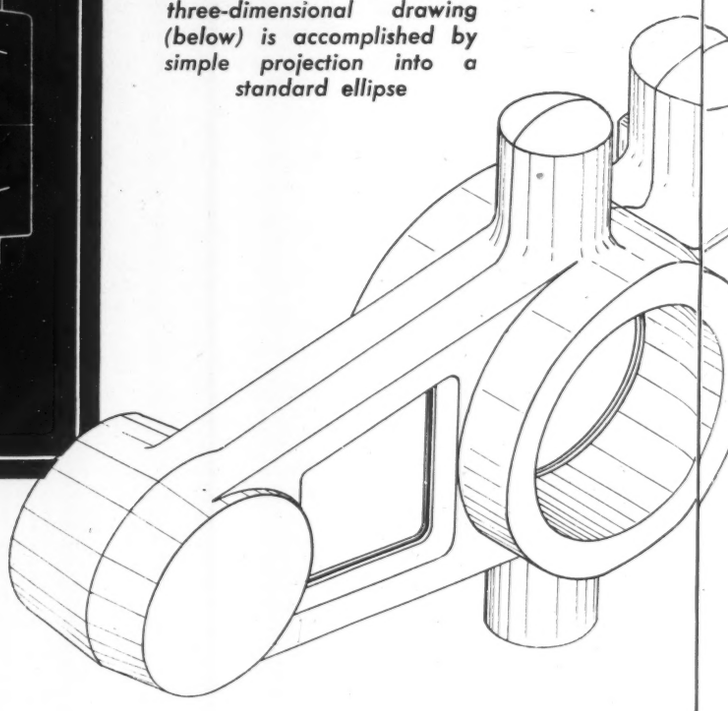


Fig. 1—Conversion of orthographic drawing (left) to three-dimensional drawing (below) is accomplished by simple projection into a standard ellipse



Simplified Three-Dime

A new technique, which requires no artistic ability, makes possible the production of three-dimensional drawing using only the conventional compass, T-square and triangles

FAILURE after failure to make three-dimensional drawing a practicable proposition has resulted in a general belief that it will remain within the province of a few gifted artists outside the engineering drawing office. Such failures naturally cast a shadow of suspicion on any new claim of success but, in spite of this, three-dimensional drawing such as illustrated in *Fig.* 1, is simply a matter of a new technique with the old familiar instruments.

In making an analysis of this new technique *Fig.* 2 will be helpful. It shows a white cube with black circular disks mounted centrally on each face. The cube is drawn in four different positions. The results were obtained by using normal projectional methods without the inclusion of perspective. In spite of the latter having been omitted no one can honestly say that the drawings represent any solid other than a cube. By comparison of the views it is found that the effect of three-dimensionality is due to the angular positioning of the receding lines combined with projec-

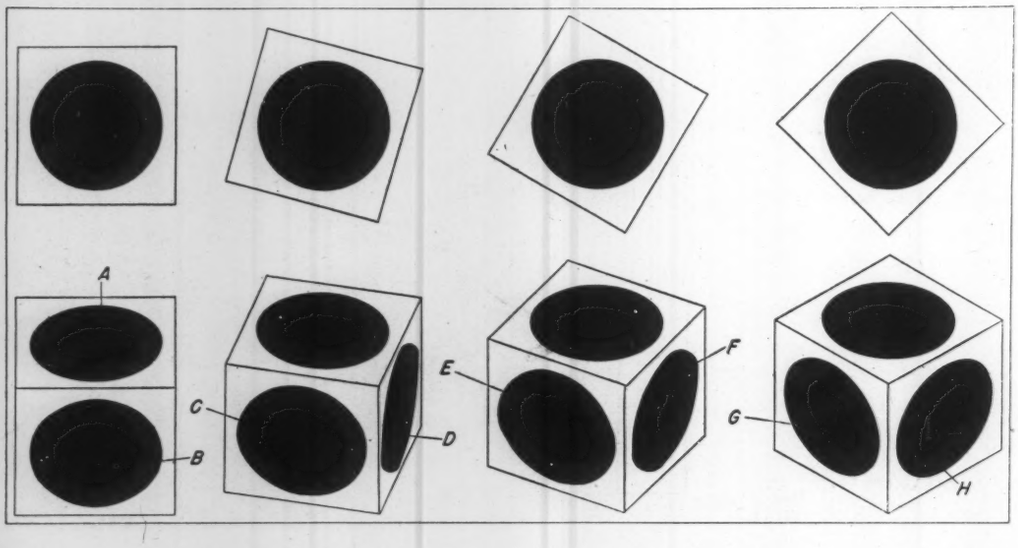


Fig. 2 — Cubes drawn three-dimensionally without the use of perspective. All of the six different ellipses, which depict circular disks, were drawn with a conventional compass

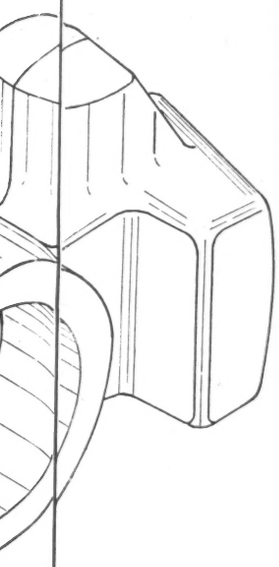
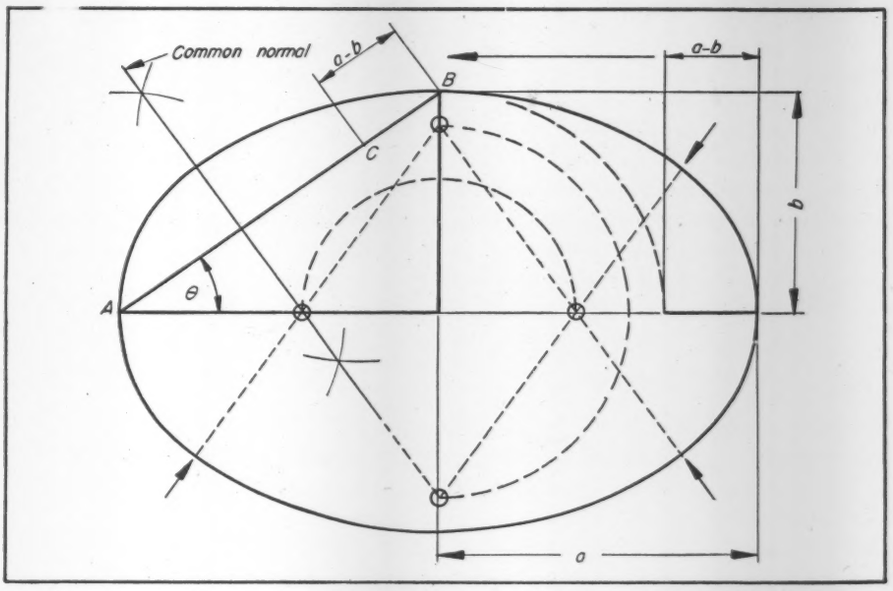


Fig. 3 — Right — Construction of basic ellipse. With major and minor axes lengths known, difference between semiaxes is laid off on chord AB. AC then is bisected and the common normal drawn. Centers of arcs of ellipse are ringed



mensional Drawing

By W. E. Walters
President, Institution of Engineering Draftsmen and Designers
London N.3., England

tional foreshortening. It follows that the use of perspective principles may be ignored without sacrificing clarity.

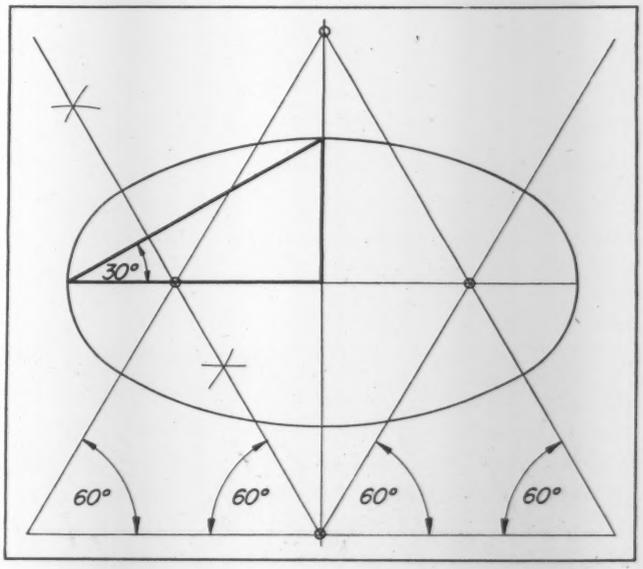
Considering the circular disks on the cube, it can be seen at a glance that they are all of identical size, yet the effect of recognizing them as being all the same is produced by half a dozen differently shaped ellipses. Furthermore, the ellipses are not only different in size and shape but they vary in angular positioning with respect to the outlines of the cube.

Three-dimensional drawing generally presents a formidable list of interdependent changes: Dimensions shorten, angles change and circles become ellipses of different size, shape and position. In *Fig.* 2 there are six different ellipses which were constructed with a conventional compass. Even though they are not true ellipses they are considered satisfactory. Since the desired effect is produced there is no need to plot mathematically accurate elliptical curves. In fact, they are as unessential as perspective in three-dimensional engineering drawing.

In *Fig.* 3 an ellipse is shown as the combination of two pairs of suitable circular arcs. The degree of accuracy and effect depends on selection of the appropriate radii. Knowing the major and minor axes, the difference between the semiaxes $(a-b)$ is laid off on the chord AB, resulting in AC. Next, AC is bisected and the common normal drawn. The centers of the required arcs (shown ringed) lie in the intersections of the common normal and the lines of the axes. This method of approximation is applicable to all shapes and sizes of ellipses.

The method shown in *Fig.* 3 can be simplified further under certain conditions. If this simplified method is applied to various shapes of ellipses it will be found that the common normal may assume any angle to the major axis between the limits of 45 and 90 degrees, both exclusive. At 45 degrees, the ellipse becomes a circle and at 90 degrees it becomes a straight line equal to the major axis. The most convenient angle between these limits is 60 degrees, and the consequences of adopting this angle are most interesting. It is admirably suited to provide the mechanical solution to the whole range of three-dimen-

Fig. 4—Below—Standard ellipse, which is constructional simplification of basic ellipse shown in Fig. 2. In this ellipse, the sum of the long and short arc radii is equal to the major axis, and their difference equals the minor axis



sional engineering drafting problems.

When the common normal assumes an inclination of 60 degrees to the major axis, angle θ in *Fig.* 3 becomes 30 degrees. The ellipse shown in *Fig.* 4 satisfies these conditions and has been adopted as standard in this method of three-dimensional drawing. Study of this standard ellipse reveals a surprising relationship between its axes and the radii employed to draw its outline. This relationship is: The sum of the radii of the arcs is equal to the major axis and their difference is equal to the minor axis.*

Standard Ellipse Is Ideal in Many Ways

There is no other ellipse with such extraordinarily convenient proportions that offer maximum facilities for rapid construction. It is a simple matter to reduce the method of *Fig.* 3 to the one shown in *Fig.* 4. A simple procedure determines automatically and simultaneously the arc centers (shown ringed in *Fig.* 4), the radii of the arcs, the lengths of the arcs, the points of mergence, and the length of the minor axis.

* Readers are invited to establish formulae for the radii in terms of a and b from the geometrical method illustrated in *Fig.* 3 and compare results with the following: If major axis = 1 then minor axis = 0.5774 at the stage when the common normal is at 60°. Large radius $R = 0.7887$ and small radius $r = 0.2113$. $R + r = 0.7887 + 0.2113 = 1.0000$ (major axis). $R - r = 0.7887 - 0.2113 = 0.5774$ (minor axis). Also the sum of the axes is $2R$ and their difference is $2r$.

Referring back to the list of interdependent variables which become apparent upon study of *Fig.* 2, there still remains the task of finding the line combination which belongs to the standard ellipse. The projectional views of the cube in *Fig.* 2 are the result of first tilting and then rotating the object (see *Fig.* 6). It will be noticed that the angle of tilt remains constant throughout the rotational changes, shown in steps of 15 degrees. Comparison of the ellipses on the top face of the cube reveals that they are all identical in shape, size and positioning (ellipse *A* in *Fig.* 2) in spite of progressive rotation. It is only natural that this should be so, since a wheel always appears as an ellipse whether stationary or in motion. Consequently, rotation can be ignored in this instance as it does not affect the three-dimensional appearance. Angle of tilt remains as the only unknown quantity. The numerical value of this angle need not necessarily be determined by means of the trigonometrical function involved, the thing which really matters is that this tilting angle should correspond exactly to the one which projectionally changes a circle into the standard ellipse. The simplest drawing technique to achieve this uniformity of tilt is shown in *Fig.* 5. The orthographic plan view of the cube is fitted into its circumscribed circle so that the four corners lie on the periphery. It is self-evident that they must also lie on the periphery of the standard ellipse.

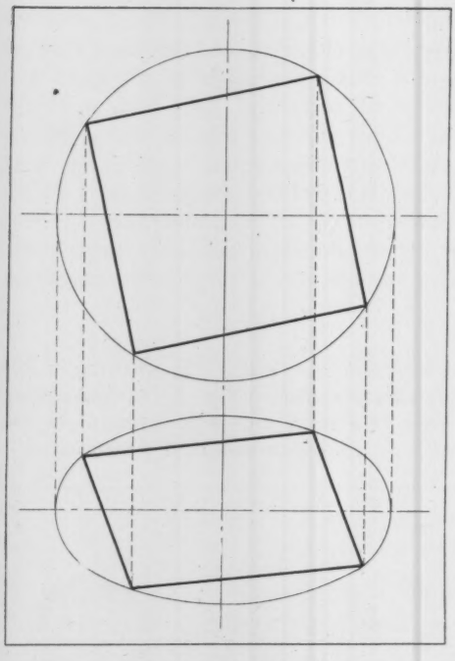
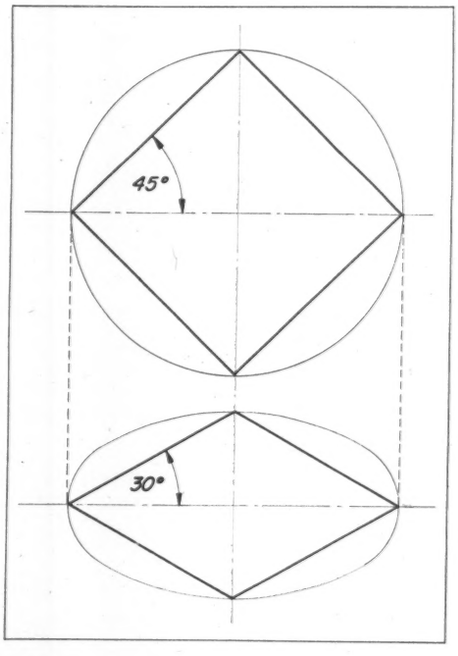
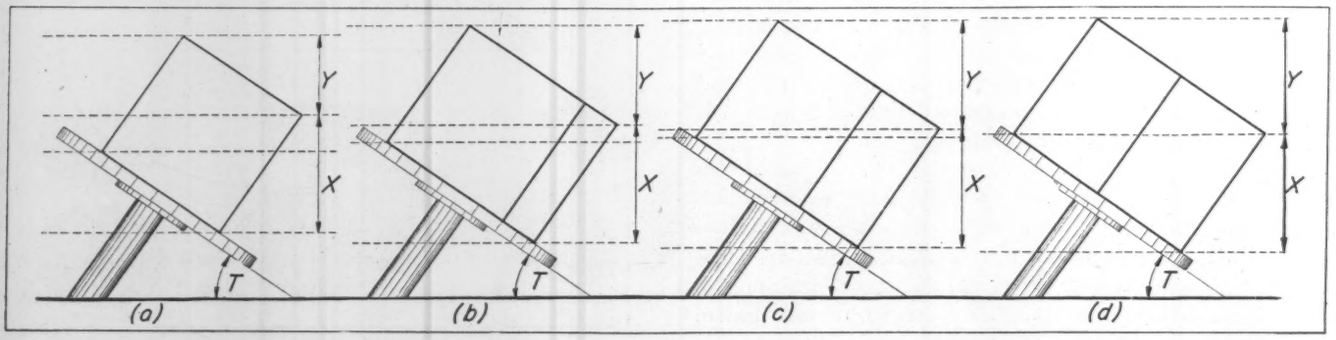


Fig. 5—Left—How plan view in orthographic drawing is projected into standard ellipse to produce three-dimensional counterpart. Since corners of square lie on periphery of circle, they must lie on periphery of ellipse also

Fig. 6—Below—How verticals of cube (X) foreshorten as cube is rotated at constant angle of tilt (T) until, at 45 degrees, X and Y are equal

Fig. 7—Right—How top face of cube when rotated through 45 degrees, as in Fig. 6d, is projected from circle to standard ellipse





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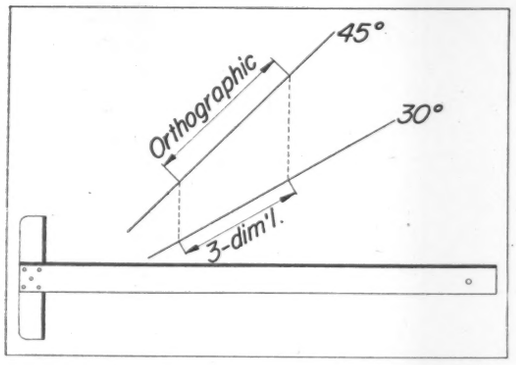


Fig. 8—Left—To obtain foreshortening of vertical dimensions, distance is laid off on 45-degree line and projected onto 30-degree line as shown

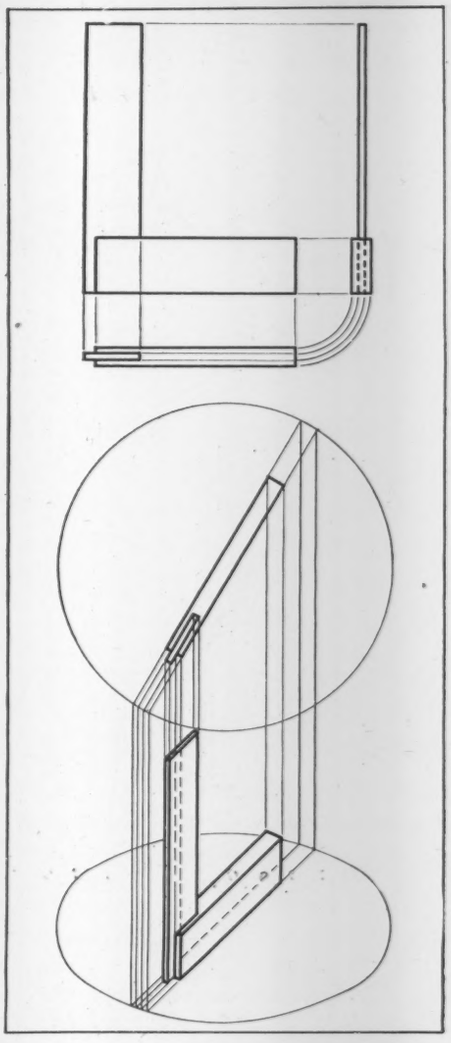


Fig. 9—Right—How orthographic drawing of toolmaker's square is converted into three-dimensional drawing

Having arranged circle and ellipse in their correct projectional relationship, the corners are easily located as shown. Thus, without any calculation, there has been effected a conversion of the orthographic plan view to its three-dimensional appearance at the stipulated angle of tilt. At the same time two more problems have been solved, namely the change of dimensions and the change of angles. Having successfully tilted the top face of the cube into the required three-dimensional position, *Fig.* 5, the next question is: What happens to the lines which describe the rest of the cube? In other words, how is the picture completed? The problem is one of determining the correct ratio of foreshortening for the verticals. A moment's reflection will show that this ratio must be the cosine of the tilting angle. However, as in the case of the angle, so with this ratio, the numerical value is of little use for practical purposes. It would mean multiplying every vertical dimension by 0.8165. It is my intention to free the draftsman not only of the necessity to use special equipment but also of the need to resort to mathematical calculations during drafting.

The standard ellipse was the result of deliberate arrangement for the convenience of the draftsman and proved exceedingly satisfactory. Thus there is no reason why the whole cube should not be arranged in the simplest position for drafting. *Fig.* 6 illustrates the rotation of a cube at the correct angle of tilt, the projection lines being shown dotted. These projection lines should be studied carefully throughout the rotational stages shown. There is an important change in the relationship of the projectional lengths which are marked *X* and *Y*, *X* representing the foreshortening of the verticals. The distance *Y* steadily grows until eventually it is equal to *X*, which happens after rotating the cube through 45 degrees. *Fig.* 6*d* shows that at this stage the center projection line coincides with the space diagonal of the cube. In consequence, the cube must now be equally and evenly balanced about the center projection line and it follows that all faces of the cube will appear equal in outline. *Fig.* 2 (ellipses *G* and *H*) shows this also. It means further that projectional foreshortening is *equal* for horizontals and verticals, that all ellipses will be of standard shape, and that they will occupy the same relative position in the projected picture.

This is a notable coincidence of ideal conditions which solves the problem almost automatically. In *Fig.* 7 is shown the orthographic plan view of the cube in the 45-degree position. The circumscribed circle is tilted to assume the outline of the standard ellipse and the four top corners of the cube are located in the same way as in *Fig.* 5. The rotational angle of 45 degrees appears as 30 degrees in the projected view. It has been deduced previously that horizontal and vertical foreshortening must be the same in this position. Consequently the projected length of the verticals is as simple as the diagrammatic reduction in *Fig.* 8. Whenever it is necessary to obtain the foreshortening of a vertical dimension the draftsman need do no more than mark it off on a 45-degree line and project it down onto a 30-degree line. It will be obvious that a constant tilting angle must produce a constant ratio of vertical foreshortening (the distance *X* in *Fig.* 6 is the same in every case).

The principles so far evolved are applicable to all prismatic and cylindrical shapes. It means in effect that a good 75 per cent of the common engineering shapes can be dealt with already. No attempt has been made to differentiate between trimetric and isometric methods, although both are covered.

In putting this technique to work in a practical way, attention is called to *Fig.* 9, which illustrates the procedure of translating an orthographic drawing of a toolmaker's square into a three-dimensional view. Remembering the development in *Fig.* 5, a circle is drawn (any size) around the plan view and projected straight into the standard ellipse. Conversion of all angles and dimensions occurring in the horizontal is thereby automatically effected. For the vertical dimensions, refer to the 45 to 30-degree projection shown in *Fig.* 8. The technique is demonstrated further in *Fig.* 10 showing a prop-socket which is a combination of prismatic and cylindrical shapes and is, therefore, typical of most engineering components. The vertical lengths are obtained by the 45/30 method, while

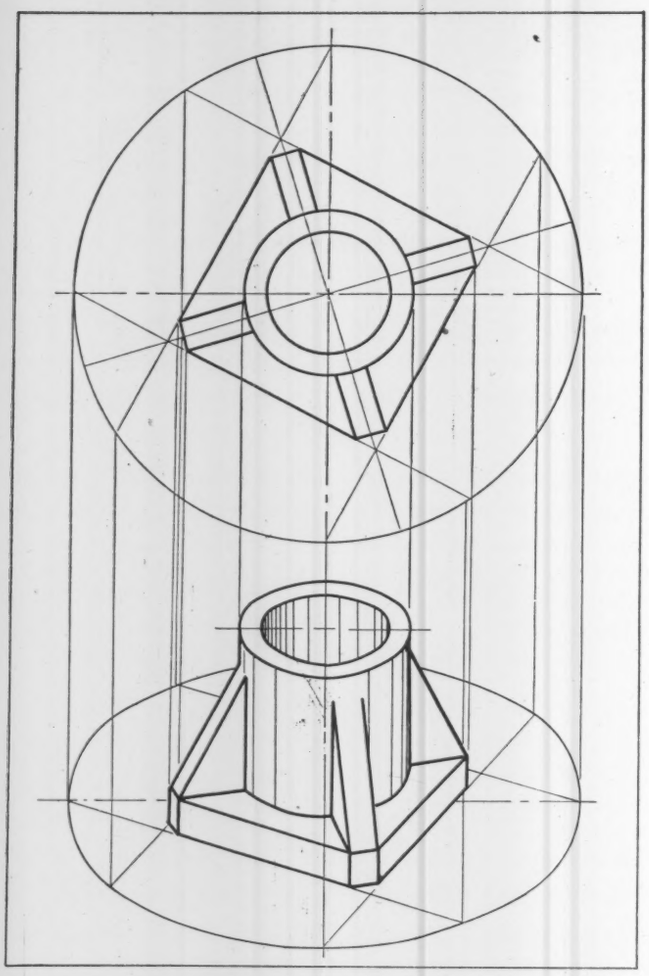


Fig. 10—Typical machine component is this prop-socket. All points in horizontal plane are established in ellipse by simple projection from circle

all other items are the direct result of projecting from circle to ellipse.

Summarizing, it is found that this technique of three-dimensional drawing is a special case of orthographic projection; that the component may be rotated into any position as long as the angle of tilt is maintained; that the conversion of horizontal dimensions and angles is brought about by projection from a circle to a standard ellipse; and that the vertical foreshortening is constant. Recognizing and understanding these facts, the draftsman can produce the actual appearance of all straight-line shapes in any position. There is, however, one limitation which concerns elliptical outlines. He is restricted to a choice of the "ideal" position in respect to round objects because the mystery of the odd ellipses in *Fig.* 2 thus far remains unsolved. The final question which will have to be answered is how can a cylindrical shape be drawn from any angle.

Verticals and Horizontals Interchangeable

In connection with *Fig.* 6*d*, it was deduced that verticals and horizontals receive identical treatment. Does this mean that they are interchangeable; that in fact there is no difference between drawing a cylinder on its base or on its side? It sounds paradoxical but *Fig.* 11 proves that the answer is: Yes. There is an unfinished equilateral triangle around the cylinder and if the whole is turned so that each of the sides becomes horizontal in turn, the cylinder does indeed stand on its base and lie on its side accordingly. Thus it is possible to draw a corner fitting without the slightest difficulty, *Fig.* 12. It is, of course, desirable to arrange the orthographic plan view in the ideal 45-degree position for cylindrical components of this type.

The occasions when a draftsman is forced to portray round shapes in other positions are rare. A boss on an oblique face is a case in point. There is some need, therefore, that he should be capable of dealing with the construction and positioning of nonstandard ellipses which will complete the requirements for the whole field of three-dimensional engineering drawing.

So far the ellipses in *Fig.* 2 were considered to represent circular disks. Suppose these disks were in reality cylinders inside the cube. What would they look like if the sides of the cube were transparent? *Fig.* 13 provides the answer. They are drawn individually but the lettering will readily establish the connection with *Fig.* 2. The

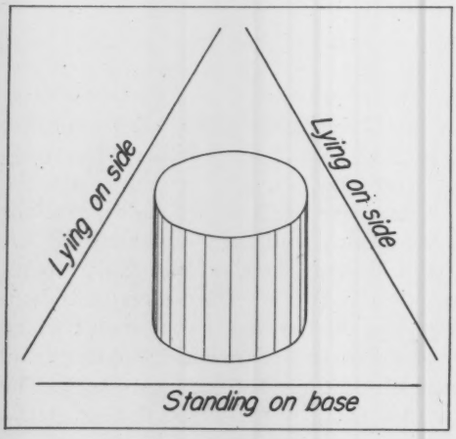


Fig. 11—Left—If illustration is turned so that each side of triangle in turn becomes horizontal, cylinder will appear perfectly normal in all three positions

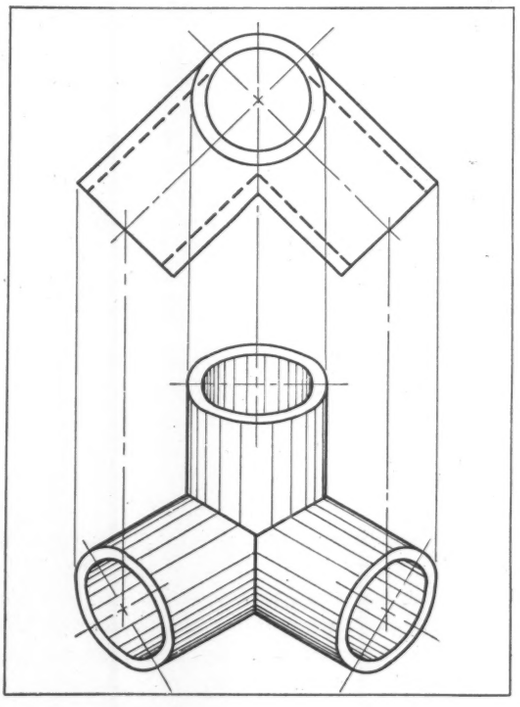


Fig. 12—Right—Drawing three-dimensional view of corner-fitting becomes simple matter using standard ellipses with orthographic plan view set at 45-degrees

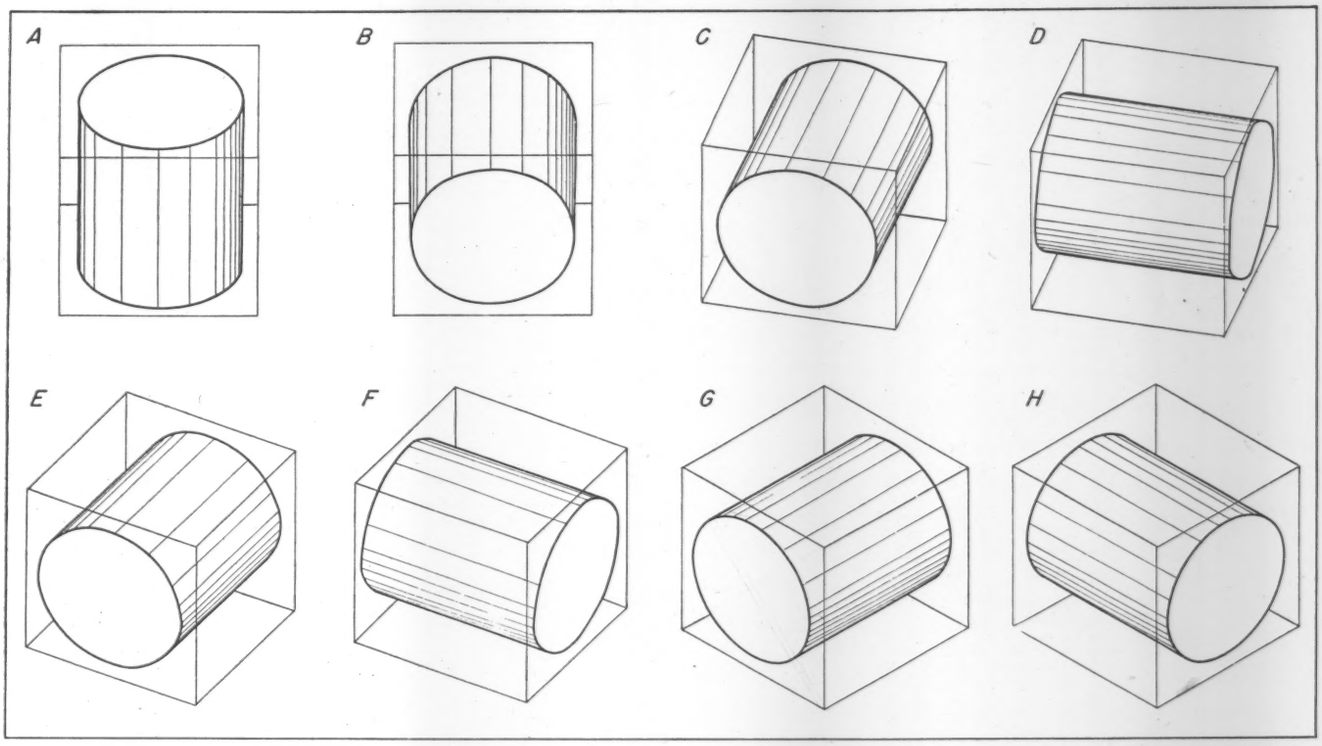


Fig. 13—Drawing cylinders inside of cubes set at various angles of rotation. Major axes of all ellipses are of same length, being equal to diameter of the orthographic circles (see Figs. 1, 4 and 6)

cylinder is depicted in eight different positions and there are, of course, eight considerably different outlines. Where is the clue to the construction of the odd ellipses? As the axes are not shown in finished views the technique of drawing is puzzling but it may be noticed that the length of the major axis—if it were visible—is constant throughout the changes shown. From previous investigation we know that the major axis is equal to the diameter of the projected circle (*Figs.* 5, 7, 9, and 10). No express mention of this fact was made since it appeared obvious, but in the light of *Fig.* 13 it assumes importance. The length of the major axis being the same in any position must mean that it never foreshortens. Thus, whatever the rotational position of the object, the length of all major axes is given with the diameter of the orthographic circles.

Positioning the Major Axis

Another point which has given rise to much controversy is the law which governs the angular positioning of the major axis. Evidently it is difficult to say what the required angle should be with reference to the T-square. If the angle of the major axis is considered with respect to the receding lines (*Fig.* 14) the problem simply disappears. The angle is always 90 degrees. The angle of the receding lines in view of the meaning of *Fig.* 5 becomes an elementary matter. Consequently, the angular positioning of the major axis ceases to be a mystery and becomes a simple matter indeed.

It will be noted that when constructing odd ellipses, in addition to length and angle of the major axis, the minor axis also must be known. In *Fig.* 14 is illustrated the case of ellipse *C* in *Figs.* 2 and 13. The end points of the minor axis which fix its length are shown ringed in *Fig.* 14. They are the result of what may be termed "projection via diagonals". The arrowheads along the "projectors" will help to make the meaning of this term more understandable and should serve as a guide for three-dimensional drafting practice.

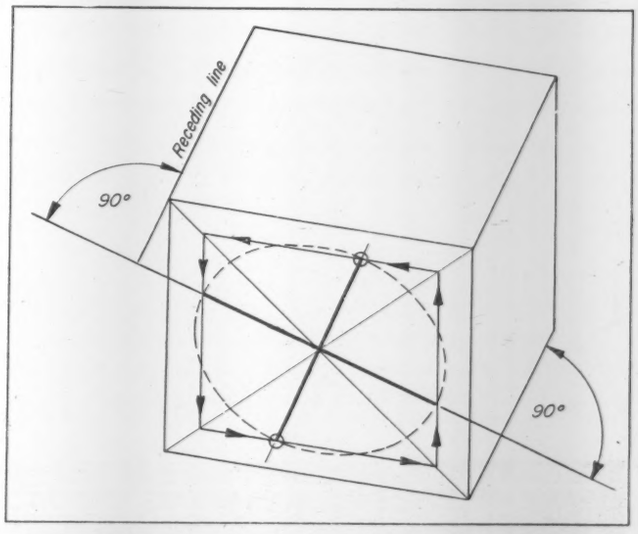
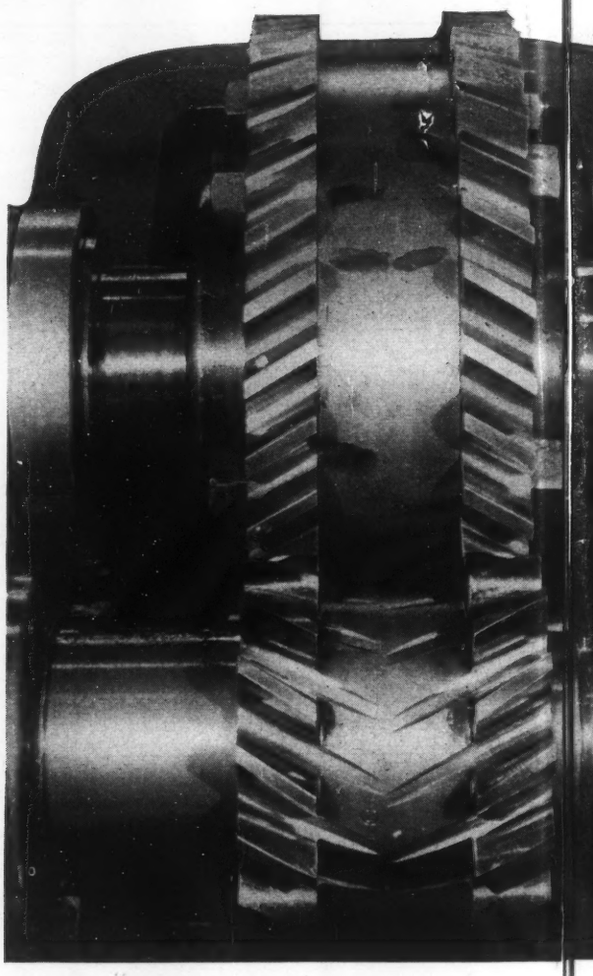


Fig. 14—How ellipse C of Figs. 1 and 12 were constructed. Angle of major axis is always at 90 degrees to receding line and determination of minor axis length is result of projection by diagonals

In view of the foregoing, it will be seen that three-dimensional drawing is in fact within the mechanical range and scope of conventional drawing instruments and that it does not call for artistic ability on the part of a draftsman nor for special equipment of any kind.

Helical Gear DESIGN



Tooth strength and wear factors determined by testing sample gears of specified material on a special machine

By E. M. Currie

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UNDER conditions of speed and load existing in present-day machines, failure of gear teeth almost always is due to the development of unsatisfactory surface conditions rather than actual breakage. Repeated application of surface stress may cause destruction of the surfaces by flaking or pitting or, in conjunction with the relative sliding, may cause breakdown of the film of lubricant. When the lubricant fails, metal-to-metal sliding contact is established and failure occurs by partial welding in the form of seizing or scuffing.

To predict the performance of a pair of gears with reasonable certainty it is therefore necessary to study the surface stresses set up by specified contact conditions and

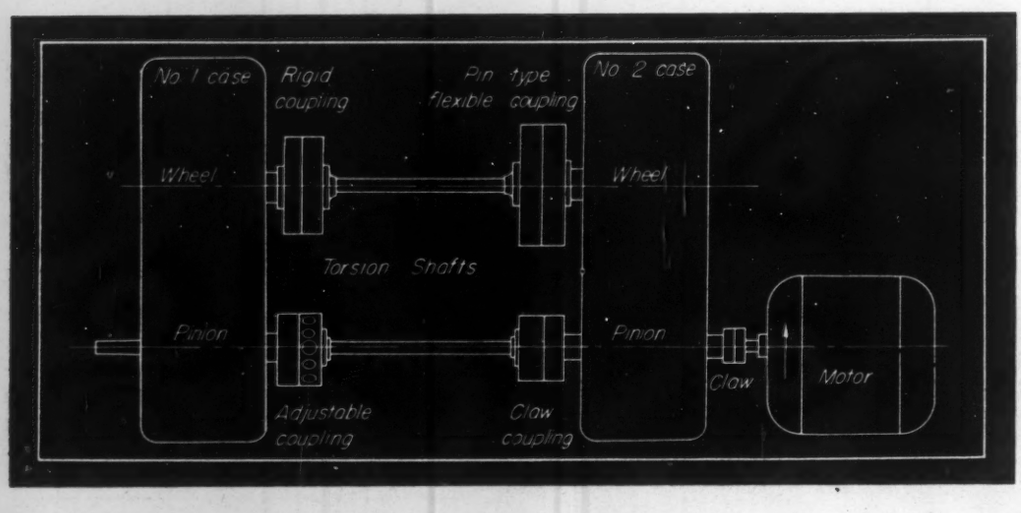
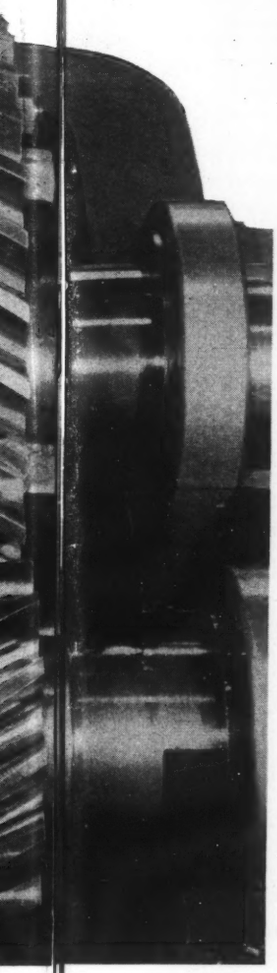


Fig. 1 — Top — Pair of Meehanite test gears in place on helical gear circulator. Right-hand gear, of different type from left hand, is pitted excessively

Fig. 2—Left—Diagrammatic layout of helical gear power circulator. Power output of the motor is absorbed by friction in the gear units



also to investigate the ability of various classes of materials and of lubricants to withstand surface stresses. In this article the evaluation of gear-tooth materials is discussed, with particular reference to an investigation of the properties of certain grades of Meehanite.

These studies were made in England at the laboratories of David Brown & Sons (Huddersfield) Ltd., and are based on the methods commonly used by British designers and incorporated in British Standard specifications. These methods, incidentally, originated with this company and are commonly referred to as the DBS system. In the following discussion sufficient information from the British standard specification is included to enable designers to apply the results to actual problems of gear-tooth design.

TEST PROCEDURE: All tests were conducted on helical gears mounted in pairs, *Fig.* 1, on a machine known as the helical gear power circulator. The circulator, *Fig.* 2, consists of two identical reduction gear cases of standard design in which are mounted two sets of gears. In one case are located the gears to be tested while the other contains gears of the same ratio and center distance but of higher load capacity than the test gears.

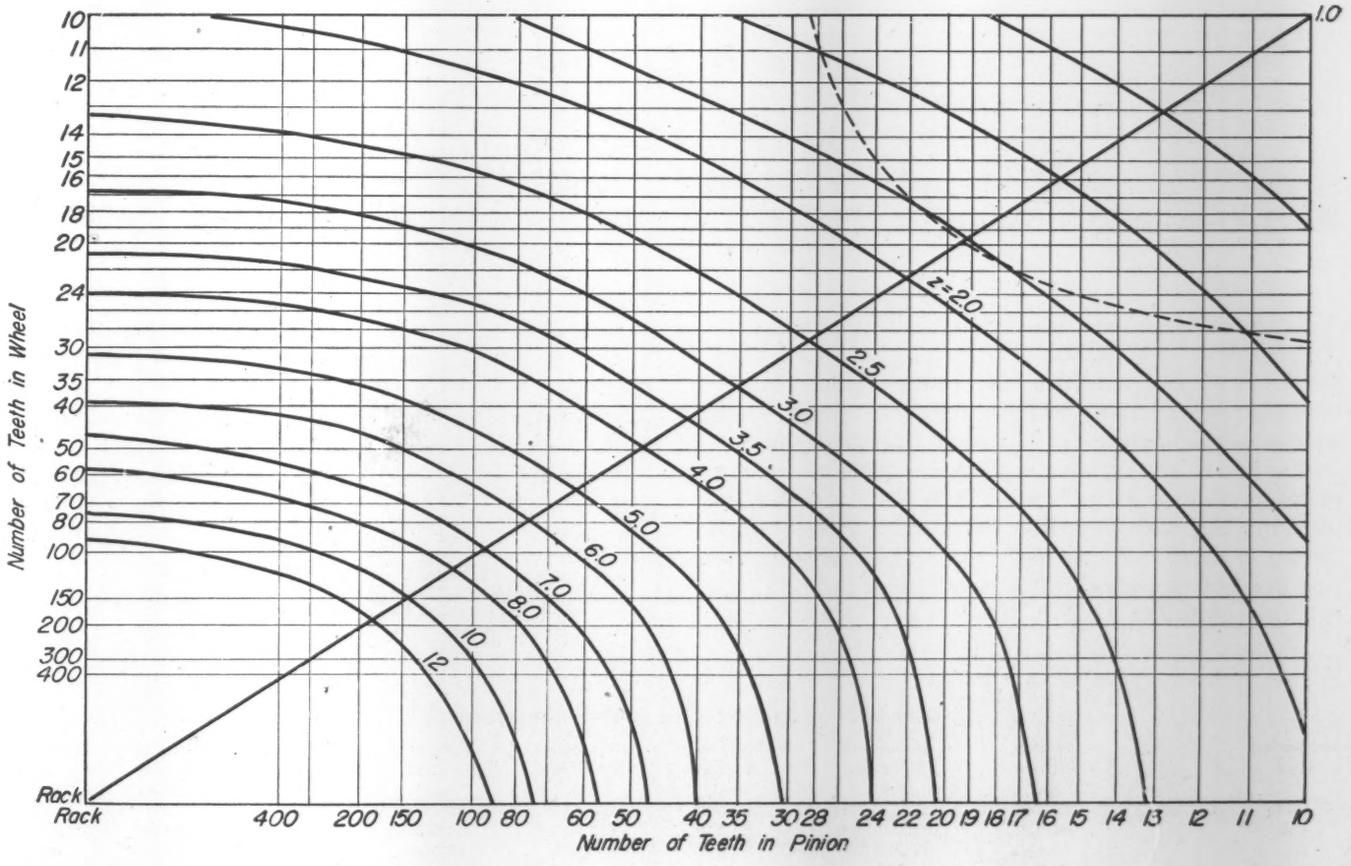
As shown in *Fig.* 2, the two sets of gears are connected by torsionally flexible shafts and four couplings one of which, the adjustable coupling, provides a means for loading the gears. In one half of this coupling are radial holes in which can be inserted a lever carrying suspended weights for exerting any desired torque. While the other half of the coupling is prevented from rotating and the coupling bolts are loosened, the weights are applied, causing angular deflection of the coupling halves due to the twisting of the shafts. The bolts, whose heads are accommodated in T-slots, are then tightened and the weights are removed. Loading for the gears is thus provided by the locked-up stresses in the shafts.

Three types of Meehanite were tested, the particulars of the castings being as shown in TABLE I. The gear blanks were machined from cylindrical castings. Two sets of tests were made, one to determine the surface stress factor and the other the tooth strength factor.

SURFACE STRESS FACTOR: In testing for surface stress factor each of the three gears was run twice, the wheel being reversed after one test and the other flank used so that the performance could be determined both in the apex-leading and apex-trailing conditions. It was found expedient, in testing two gears simultaneously, to use a gear of one type for the right-hand gear and a different type for the left-hand. By this means a direct comparison between the performance of the different types of Meehanite was possible, *Fig.* 1.

Test gears had 34 teeth of 3 diametral pitch with 31-

Fig. 3 — Below—Chart for determining zone factor for helical gears having 30-degree helix angle and 20-degree normal pressure angle



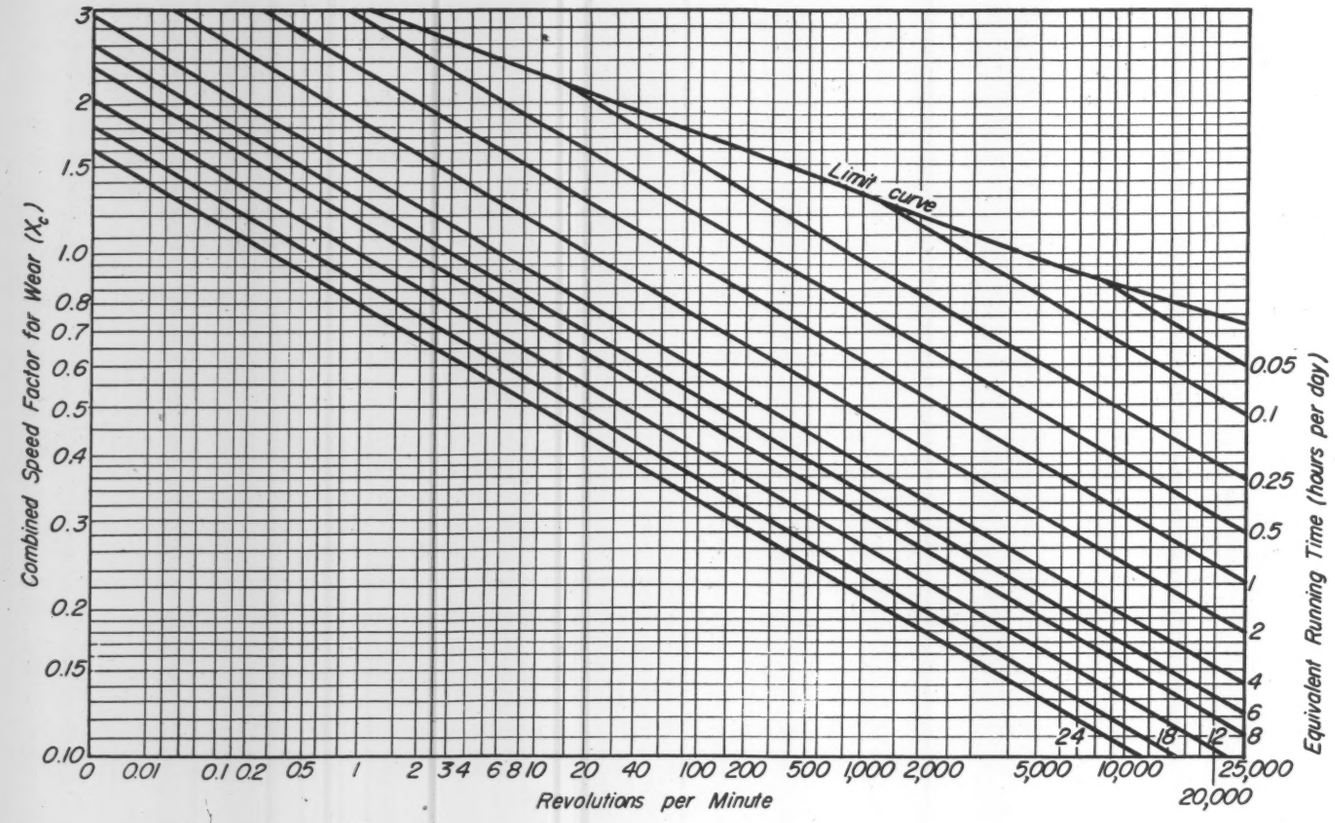


Fig. 4—Above—Chart for combined speed and running time factors for wear, applicable to spur and helical gears

Fig. 5—Below—Failure of tooth by breakage. Broken tooth also shows pitting as result of local overloading

degree spiral angle and 1-inch face width. Mounted in No. 1 case of the helical gear circulator, *Fig.* 2, they meshed with case-hardened and profile-ground 3½ per cent nickel-steel pinions on 8-inch centers. Torque loads were applied progressively in 500-pound-inch increments on the pinion, the duration of each run being one million pinion revolutions at 960 rpm. Type GA and GM gears were run simultaneously, *Fig.* 1, and both showed initial pitting at about the same load. At higher loads type GA was the first to become excessively pitted, the condition being shown in *Fig.* 1.

Maximum stress set up by contact pressure is really a super-surface shear stress the magnitude of which is dependent upon the load per unit length of line of contact and upon the relative radius of curvature of the surfaces. For design purposes, the following formula has been established as a reasonably satisfactory criterion of maximum stress:

$$S_c = \left(\frac{M}{rf}\right)\left(\frac{P^{0.8}}{ZX_c}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where S_c = surface stress factor; M = torque, pound-inches; r = pitch circle radius, inches; f = face width, inches; P = diametral pitch; Z = zone factor; and X_c = speed factor for wear.

Zone factor, Z, may be found from a chart, *Fig.* 3, which applies to helical gears having 30-degree helix angle and 20-degree normal pressure angle. For other helix angles the zone factor obtained from *Fig.* 3 should be multiplied by 0.75 $sec^2\ \sigma$, where σ is the helix angle.

Speed factor for wear, X_c, is given by the chart, *Fig.* 4. Equivalent running time, U, in cases where the loading is not uniform, is found from the relation

$$U = U_1 + U_2\left(\frac{N_2}{N_1}\right)\left(\frac{M_2}{M_1}\right)^3 + U_3\left(\frac{N_3}{N_1}\right)\left(\frac{M_3}{M_1}\right)^3 + etc.$$

TABLE I

Engineering Properties of Gear-Tooth Materials

Meehanite Type	Tensile Strength (psi)	Modulus of Elasticity (psi)	Modulus of Rupture (psi)	Compressive Strength (psi)	Fatigue Strength (psi)	Shear Strength (psi)	Damping Capacity (per cent)	Hardness as cast (Bhn)
GM	60,480	23,000,000	93,000	200,000	25,000	55,000+	21.0	217
GA	51,520	21,000,000	88,950	175,000	22,000	48,000	24.0	207
GC	41,440	17,500,000	82,000	150,000	17,500	40,000	25.0	192

where U_1 is the number of hours during which the maximum sustained torque M_1 acts at speed N_1, and U_2, M_2, N_2, etc. are the times, torques and speeds at other, smaller torques.

Analyzing the tests on type GM Meehanite, the pinion torque at commencement of excessive pitting was found to be 7125 pounds-inches. Pinion radius was 2.33 inches and the total face width of the two test gears was 2 inches. From *Fig.* 3 the zone factor, Z for a 14-tooth pinion and a 34-tooth gear, is found to be 1.8. From *Fig.* 4 the speed factor for wear, X_c, corresponding to 395 rpm wheel speed and 12 hours per day running time is 0.32. Substituting the foregoing values in Equation 1, the surface stress factor at failure is found to be

$$S_{cf} = \left(\frac{7125}{2.33 \times 2}\right)\left(\frac{3^{0.8}}{1.8 \times 0.32}\right) = 6400$$

Applying an arbitrary factor of 4, the basic allowable surface stress factor is $S_{co} = 6400/4 = 1600$. From test results of the other two types similar calculations were made, the recommended factors being shown in TABLE II.

TOOTH STRENGTH FACTORS: Similar procedure was followed in testing for tooth strength, but the gears had 68 teeth of 6 diametral pitch with 31-degree spiral angle and ½-inch face width. Initial tests on type GM with 1-inch face width resulted in no breakage at the maximum load capacity of the machine, after which the ½-inch face width was adopted. Typical failures are shown in *Fig.* 5 (complete breakage) and *Fig.* 6 (crack).

Bending stress, S_b, in the tooth is calculated from the formula

$$S_b = \left(\frac{M}{rf}\right)\left(\frac{P}{Y}\right) \qquad (2)$$

where M, r, f and P have the same meanings as before and Y is a strength factor which is dependent on the number of teeth in contact, the cantilever strength of an individual tooth, and the distribution of load over the face of the tooth. Although given the same symbol as the corresponding factor in the well known Lewis equation, it is calculated differently and may be found from *Fig.* 7. The

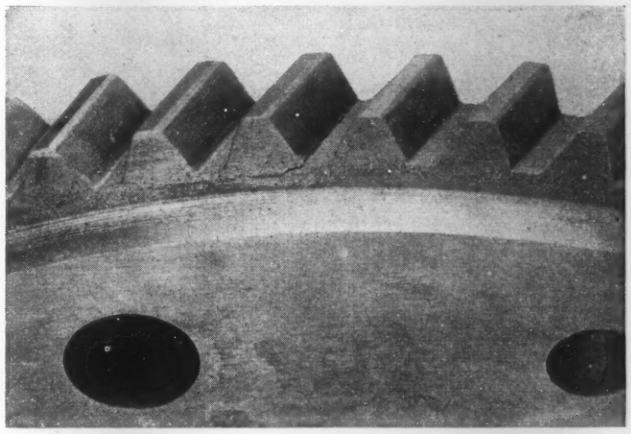


Fig. 6—Above—Example of failure of gear tooth by cracking at fillet. Magnetic examination revealed cracks on several other teeth on the same wheel

Fig. 7—Below—Strength factor, of helical gears having 30-degree helix angle and 20-degree normal pressure angle for various combinations of teeth in two gears

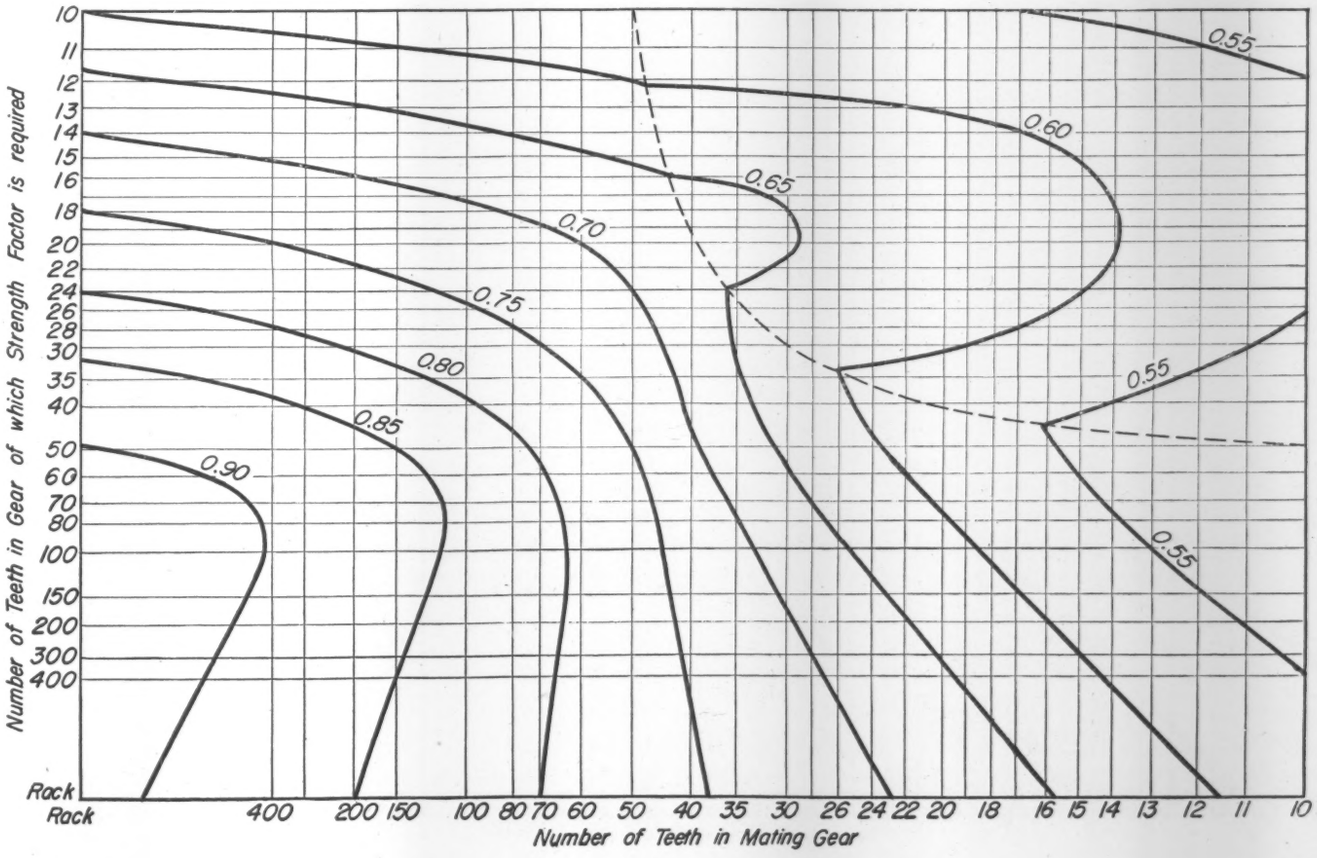


chart applies to helical gears with 30-degree helix angle and 20-degree normal pressure angle, provided the face width is sufficient to give overlap. For other helix angles the strength factor obtained from *Fig.* 7 should be multiplied by 1.33 $\cos^2 \sigma$.

Failure of the type GM gear, *Fig.* 5, occurred at a pinion torque of 4500 lb-in. For this pair of gears the value of Y is 0.65 from *Fig.* 7, the number of teeth being 68 and 28. Substituting this and other appropriate values in Equation 2, the bending stress at failure is

$$S_{bf} = \left(\frac{4500}{2.33 \times 1}\right)\left(\frac{6}{0.65}\right) = 17800 \text{ psi}$$

Permissible bending stress at this speed is arbitrarily taken as one-quarter of this. The corresponding permissible S_b at zero speed (S_{bo}) is obtained by dividing ½ S_{bf} by the speed factor applying to the test conditions. This factor, X_b, is found from *Fig.* 8 to be 0.32, hence

$$S_{bo} = \frac{1}{4} \times \frac{17800}{0.32} = 14000 \text{ psi}$$

Repeating these calculations for the other types, the results shown in TABLE II are obtained.

DESIGN: When designing gears, Equation 1 usually will be the basis for design and should be applied to both gear and pinion in the following form

$$\frac{M}{rf} = \frac{S_c Z X_c}{P^{0.8}} \quad \ldots\ldots (3)$$

TABLE II

Basic Allowable Surface Stress and Tooth Strength Factors

Meehanite Type	Surface Stress Factor (S_{co})	Tooth Strength Factor (S_{bo})
GM*	1600	14000
GA	1450	12500
GC	1400	14000

*EFFECT OF HEAT TREATMENT: Because of ready response to heat treatment, the basic factors for type GM Meehanite heat treated to hardness figures of 500 Bhn (GM1) and 429 Bhn (GM2) are as follows:
(1) Basic surface stress value 2400 for either of the heat-treated conditions.
(2) Bending stress values 16000 psi for GM1 and 17500 psi for GM2.

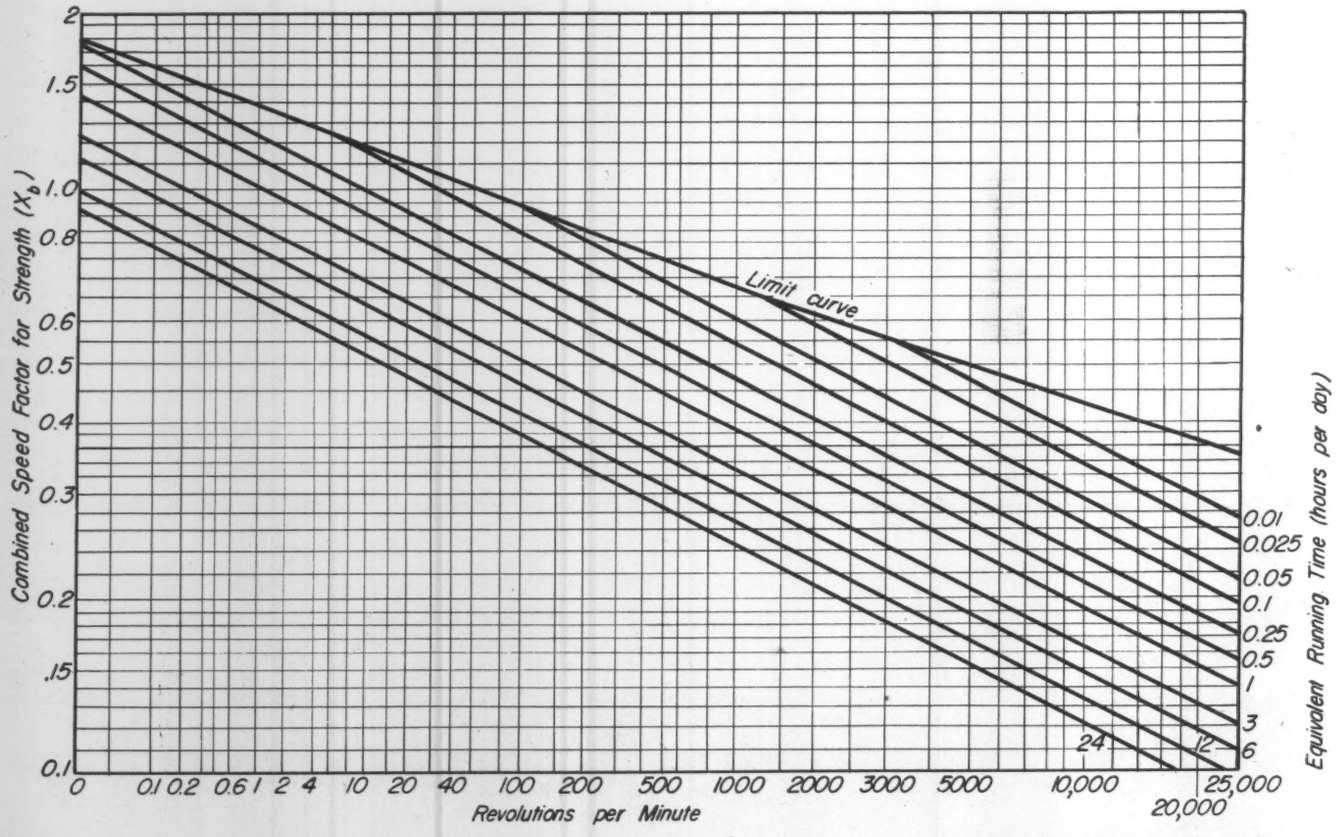
where M/rf is the tangential load per inch of face width. Strength should then be checked using Equation 2 with the appropriate speed factor included, and rewritten in the form

$$\frac{M}{rf} = \frac{S_b Y X_b}{P} \quad \ldots\ldots (4)$$

The allowable load per inch of face width then is the least of the four values found when Equations 3 and 4 are applied to the gear and the pinion.

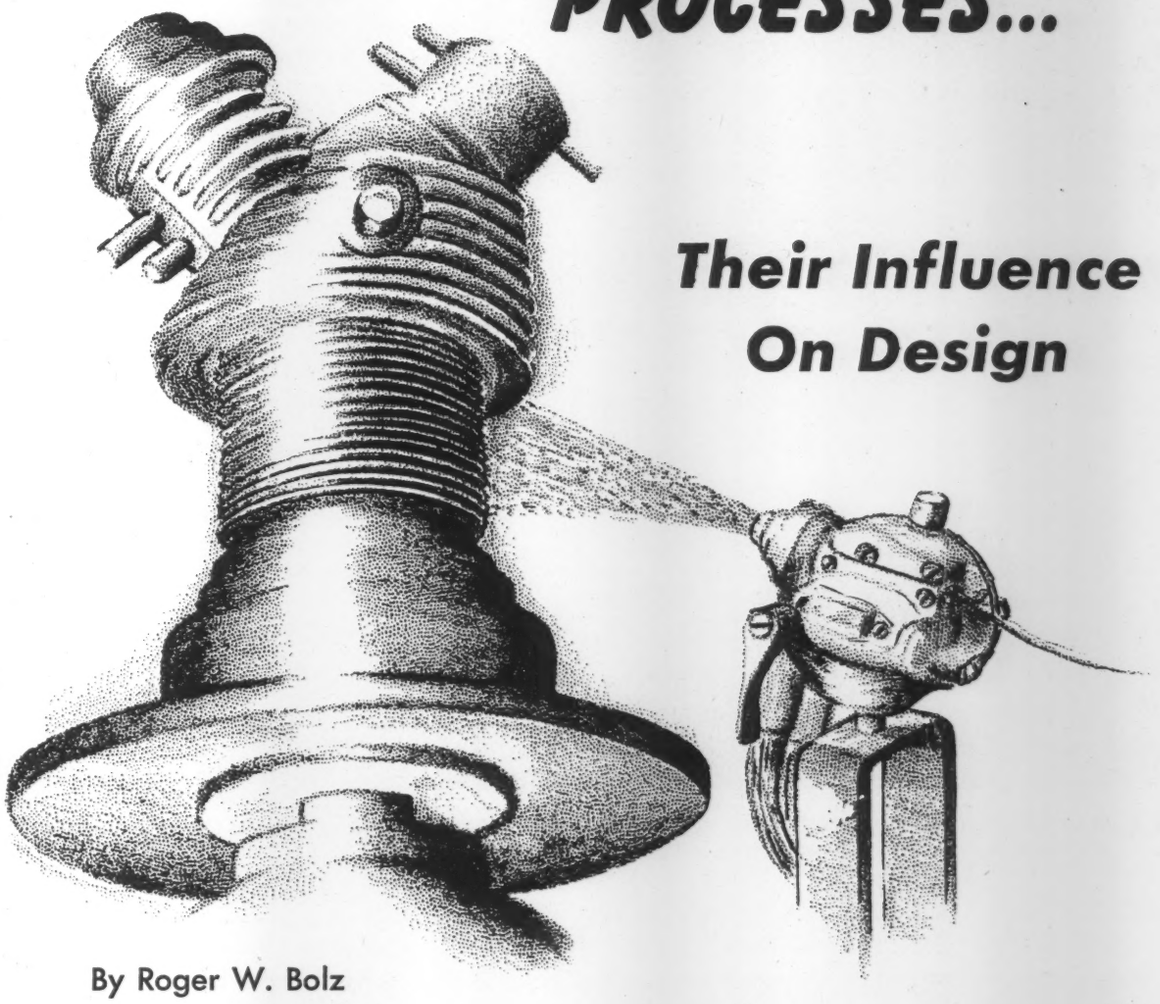
In conclusion, it should be pointed out that a greater knowledge of surface fatigue characteristics is undoubtedly necessary. Definite information will permit a more intelligent and effective choice of materials for specific conditions and neither the DBS system nor the Buckingham system in vogue in the U. S. should be considered as providing the final answer, inasmuch as so much depends upon the results of visual observation to fix the figures given for the formulas. However, it is hoped that, pending a more scientific approach, the information given in this article will prove helpful to designers.

Fig. 8—Chart for determining combined speed and running time strength factors, for spur and helical gears



PRODUCTION PROCESSES...

Their Influence On Design



By Roger W. Bolz
Associate Editor, Machine Design

Part XIX–Metallizing

SPRAYING of molten metal, commonly referred to as metallizing, like many other processes, received considerable impetus during the past few years. Although relegated by many to the general maintenance and salvage field without further thought, metallizing nevertheless is fast finding many applications along with the various other mass-production processes.

Probably the most common production application of metallizing today is that of corrosion and heat oxidation protection, *Fig.* 1. Of most interest, however, are those applications which give the metallizing process its place in design. Copper spraying can be employed to provide electrical conducting or shielding surfaces and for improvement of electrical connections as on carbon motor brushes, *Fig.* 2. Also, soldering surfaces can be provided on glass and other nonmetallic parts by tin spraying, *Fig.* 3. The most outstanding value of the process, though, lies in the design possibilities afforded in the application of special surfaces on parts which must withstand unusual conditions. Thus, low-cost materials can be utilized for such parts and sprayed metal surfaces specified for those portions which must withstand heavy wear or corrosion or which require the unusual properties of some particular metal. Piston rods, pump rods, pistons, rams, slides,

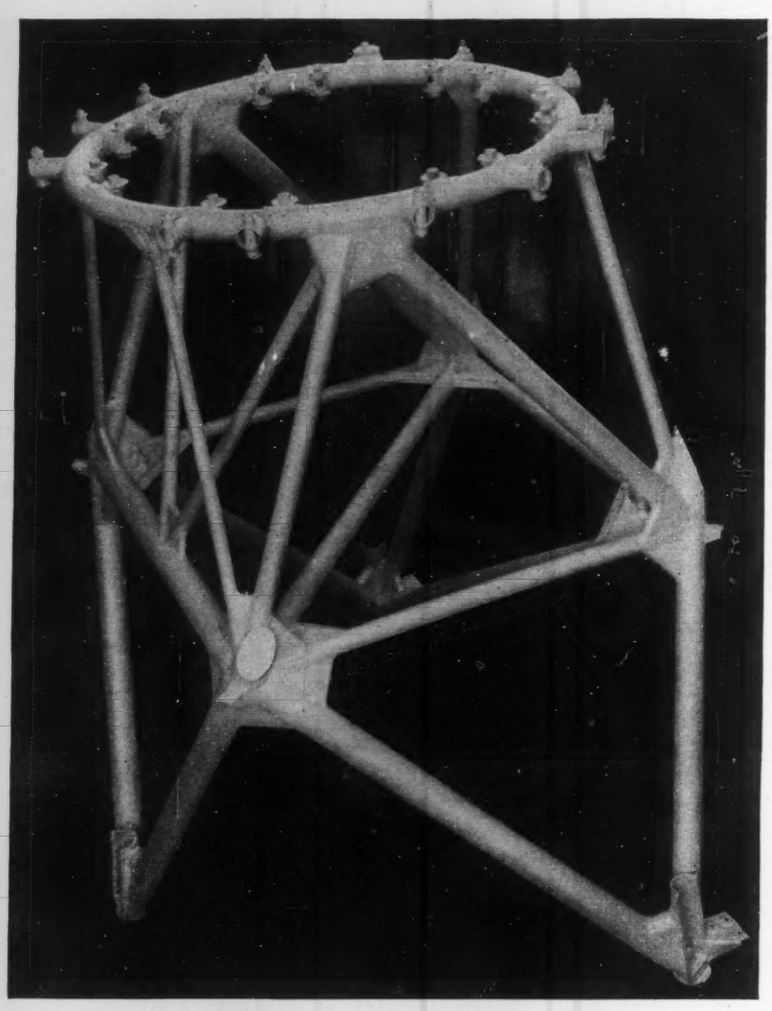
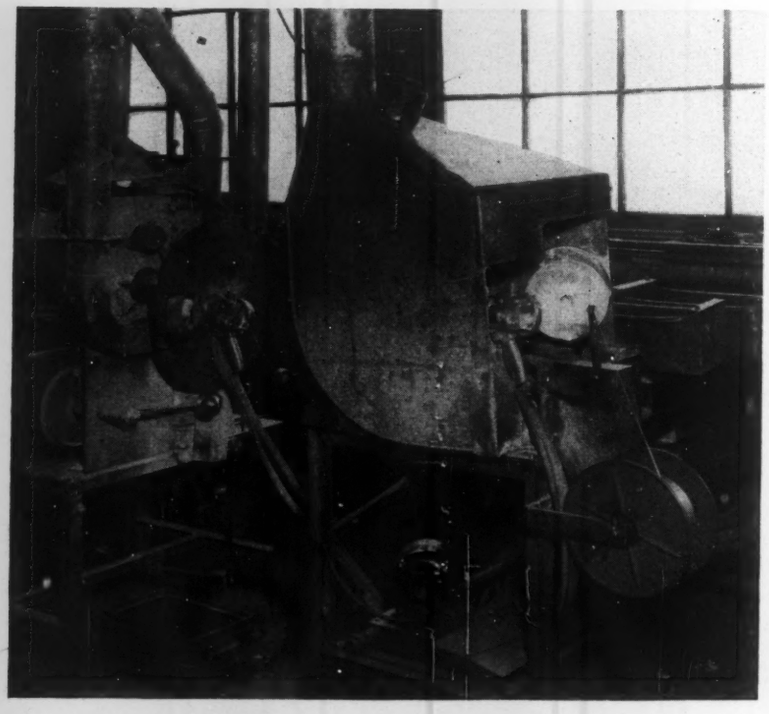


Fig. 1—Above—Corrosion protection for a steel PBM engine mount provided by sprayed 72S aluminum alloy lasts indefinitely

Fig. 2 — Below — Mechanized copper-spraying equipment provides proper electrical connection for electric motor brush leads



cams, motor brushes, chemical process equipment, circuit breaker bushings, etc., are among the multitude of machine parts utilizing metal spraying in original manufacture.

Originally conceived by Dr. M. U. Schoop of Zurich around 1911, the process in its present state of development embraces the creation of a metallic spray by means of atomizing metal in wire or powder form with a so-called spray gun. An oxygen-gas flame melts the metal—wire fed by an air turbine or powdered metal fed from a special container by means of a hose and vibrator—and a blast of compressed air picks up and carries the molten spherical globules to the prepared surface. Upon hitting the surface, the flattened particles of metal chill almost instantly and key themselves to the base material—metal, wood, plaster, stone, glass, concrete, rubber, or plastics. The bond is entirely mechanical and consequently proper consideration must be given to assure a surface which affords satisfactory bonding characteristics. Ordinarily, for corrosion applications, blasting with sand or sharp angular grit roughens the surface satisfactorily. For heavy wear-resistant coatings, though, a more certain mechanical grip surface usually must be provided.

In general, experience has proved that in the majority of cases, the materials deposited by metallizing are of superior wear-resisting quality than the parent metal. In many cases it is possible to apply much harder materials at the point where greatest wear occurs. The air-hardened characteristics of metallized deposits along with the porous nature of the deposit creates ideal properties for lubricated surfaces. A good example is the redesign of a heavy bronze aircraft strut piston to utilize a drawn steel shell metallized on the outside with 0.045-inch thick bronze, reducing weight by one-half. The advantage of porosity in lubrication applications, however, becomes a disadvantage in certain cases when the coating is to resist the penetration of fluids.

Sharp Edge or Point Bearing Undesirable

Ordinary sprayed metal, it is well to remember, cannot be used on those machine parts where it is desired to build up a sharp edge, or on parts where it will be subjected to point impact or bearing. Again, one of the important factors to consider in determining the economics of a metallizing application is the value of the part itself. Metallizing is relatively expensive and, therefore, is only practical on intricately machined pieces representing a large amount of labor or material costs. Spraying can be utilized to assure excellent wear or corrosion resistance on required areas, eliminating the necessity for making an entire part from hard-to-machine, expensive or critical materials.

Acceptable coatings of stellite can be depo-

sited by metal spraying. These coatings are especially suitable where the maximum in both wear and corrosion resistance are desired. In fact Stellite may be deposited easily on parts of bronze, aluminum or copper—a useful application not possible by any other means. Also of interest is the fact that though powder spraying equipment is simpler and lighter in weight, it is more difficult to handle and, with the exception of zinc, metals are more expensive in powder form than as wire, depositing efficiency is lower, and more weight of powder is necessary to obtain a specific weight of deposit. Powder guns cannot be used to deposit a usable finished surface of the higher melting point metals such as steel, Colmonoy alloys, etc., so their field ordinarily is limited to easily melted metals—aluminum, zinc, etc., as well as nonmetallics such as rubber, plastics, and low melting point vitreous materials.

Metallizing with powders of the higher melting point metals previously mentioned, however, is successfully carried out by what is now referred to as "spray welding". Metal powder, applied to a base metal in conjunction with chromium boride crystals by means of a flame gun, is melted and permanently bonded to the base metal with a welding torch, induction heater, or controlled-atmosphere furnace. This method is particularly effective where hard, wear-resistant facings are desired which must withstand abuse, wear, impact, and have sharp edges, *Fig.* 4, but is limited to thicknesses of 0.060-inch maximum.

No definite limits exist as to the maximum practical thickness or overall areas of sprayed coatings except those imposed by the economic aspects of the application. Coatings, as a rule, can be any thickness from 0.002-inch upwards. Generator armatures, utilizing a sprayed copper deposit approximately ¾-inch thick on a 6-inch diameter armature shaft, have been produced successfully. The sprayed copper surface which formed the contact area for the brushes, being air quenched naturally in the process, proved in service to be harder and more wear resistant than the original copper. Lathe beds, metallized with steel and finish ground, also have been produced, resulting in a precision bedway with excellent lubrication properties and wear resistance equal to that of hardened steel.

For many applications the ordinary type of hand-operated gun is used successfully but, where production is high and uniformity desirable, mechanized setups can be employed. Spraying of the cylinder barrels shown in *Fig.* 5 is a typical example where an automatic metal-spraying machine falls just short of being completely mechanized, a hand operation being required as a final touch up. Metallizing of an engine cylinder is done in 75 seconds, each one passing through six work stations.

DESIGN: Adequate consideration of atmospheric and chemical corrosion as well as heat oxidation which must be coped with cannot be overemphasized in the design of machine parts. Inasmuch as severe corrosion may reduce the strength and ductility of a metal drastically, in certain cases even small amounts are unsafe on relatively thin stressed sections.

Pure aluminum is excellent for use on duralumin sheet or castings, and sprayed zinc on steel often can be specified where hot galvanizing would be too costly or impossible. Zinc, cadmium and aluminum, being anodic to iron and steel, furnish excellent protection regardless of porosity;

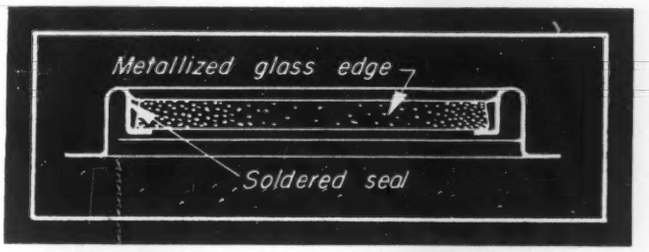


Fig. 3—Above—Pyrex glass window soldered directly to a metal frame by means of metallizing the edge, is liquid, gas and airtight

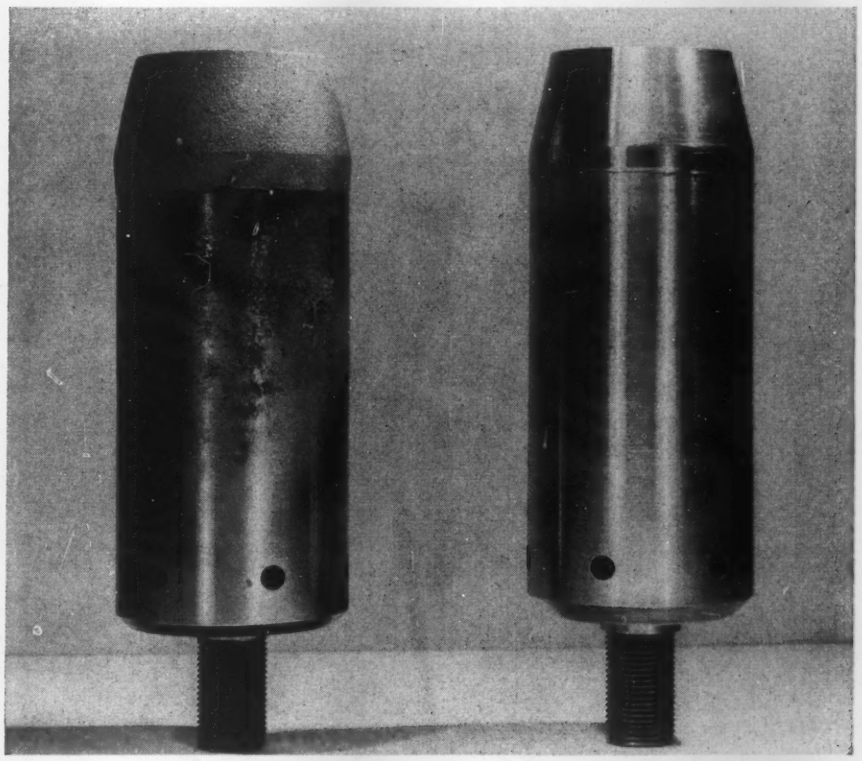


Fig. 4 — Right — Large mandrel with hard-faced nose section shown at left after spray welding but before bonding, right, after finishing

however, when lead or stainless steel are desirable, coatings must be heavy enough to prevent penetration through the pores to the base metal or the part must be processed to close the pores of the spray coat. At elevated temperatures aluminum is usually preferred for protecting steel and, where maximum protection is desired, the coating can be processed to create an alloying effect equivalent to that obtained by calorizing.

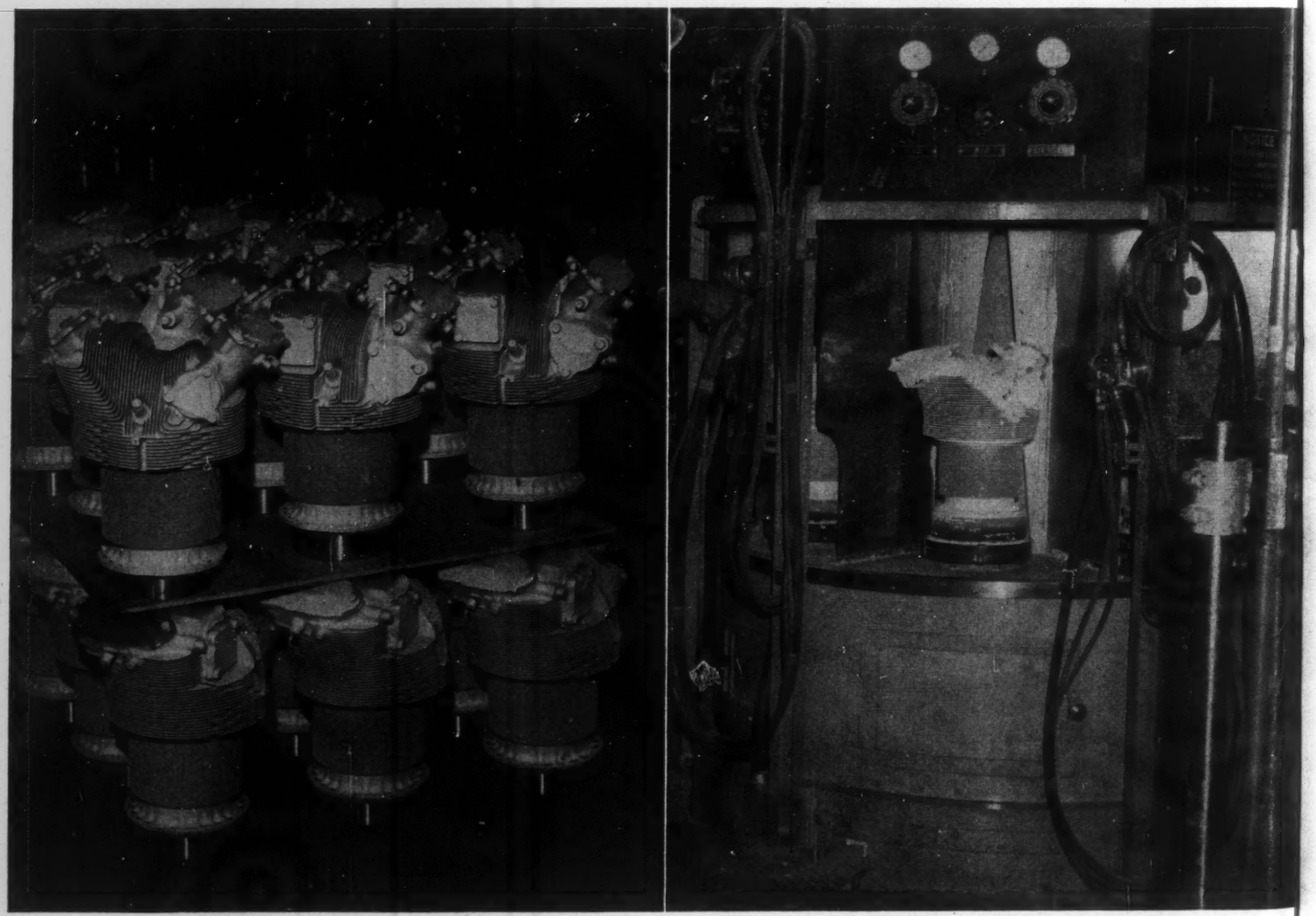
Mechanical bonding satisfactory for plastics, corrosion-protection coatings and spray welding can be provided on parts by merely specifying a thorough sand or steel grit blast finish. No other preparatory consideration is required, as with the application of heavier special surfaces which are finish machined after depositing.

Several methods of preparing surfaces for metallizing are in common use. One is by rough turning or grooving and knurling. Suited primarily for surfaces of rotation, the rough turning is literally a crude thread of 18 to 20 pitch approximately 0.040-inch deep, while the grooving method utilizes closely spaced grooves made by a tool 0.045 to 0.050-inch wide, about 0.025-inch deep, spaced about 0.015 to 0.025-inch apart and knurled to form dovetails, *Fig.* 6. Grooving tools are specified to produce corner radii of about 0.020-inch maximum to minimize the stresses set up, and because of this feature the grooving method is preferred. The second or electric bonding method, a fairly recent development useful for any type of surface, provides the fastest, most economical and satisfactory surface preparation and, most important, does the least structural damage to the part. Design for this method consists only of specifying the portion to be sprayed sufficiently undersize to suit the requirements. Ends, where undercut, should be smoothly rounded, *Fig.* 6, and the radius can be as desired. Bonding is not unlike a welding process, an electrode holder with six nickel electrodes is stroked across the prepared surface to produce a light, frothy, bubble-like layer of nickel about 0.006-inch in depth. Maximum mechanical bonding, especially at the point of junction, is assured by this method and is preferable in most cases.

Sprayed metals are much like cast metals of the same analysis, but their density is about 10 to 15 per cent less and they have little tensile strength or elasticity. Their resistance to compression, though, is good and makes them ideal for oil-impregnated bearings and bearing surfaces. It follows naturally that, except for spray welding, coatings should never be designed so as to taper out; a definite shoulder is desirable in all cases. Characteristics of sprayed metals also preclude the possibility of cutting threads in coatings.

Where the qualities of Stellite are desired, including complete corrosion resistance, coatings should be at least 0.030-inch thick to eliminate porosity. However, coatings

Fig. 5—Below—Automatic metal-spraying machine finish coats Cyclone engine cylinder with aluminum in 75 seconds



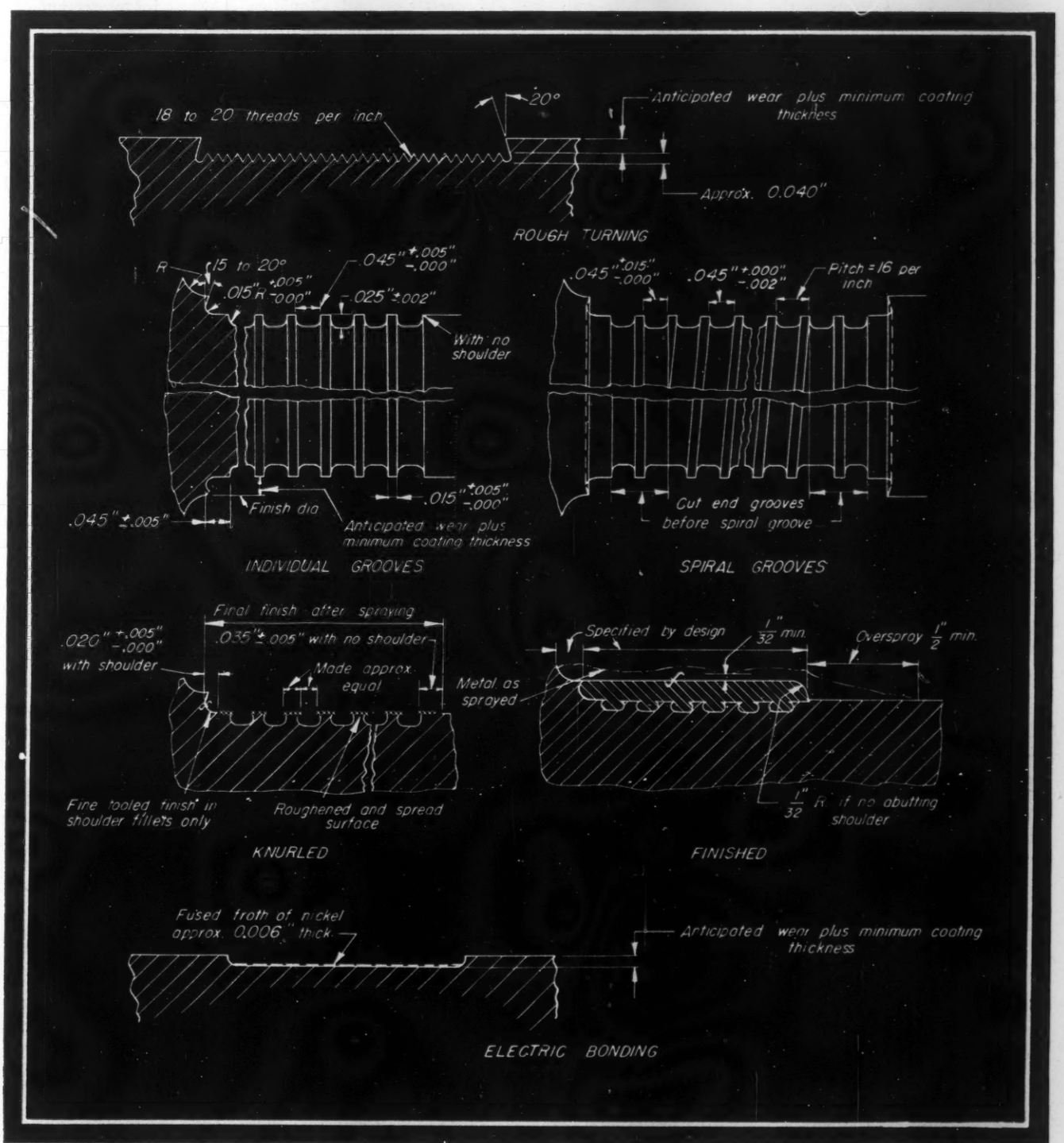


Fig. 6—Methods of surface preparation for spraying. Electric bonding method is usually most satisfactory

may be any thickness otherwise. Generally, where wear surfaces are specified, consideration is given the maximum amount of wear anticipated and to this is added a minimum basic coat, depending upon part size, to obtain the correct depth for the spray coat. Using diameters as an indication of part size: For 1-inch or under, 0.010-inch is added to the maximum expected wear figure; for 1 to 2-inch, 0.015-inch is added; for 2 to 3-inch, 0.020-inch; for 3 to 4-inch, 0.025-inch; for 4 to 5-inch, 0.030-inch; for 5 to 6-inch, 0.035-inch; for 6-inch and over, 0.040-inch is added to the maximum wear figure.

The foregoing figures apply to all such work except press fits. Here the minimum thickness may be 0.010-inch on the radius after machining, regardless of diameter. Tests on driver axles for locomotives designed with a 0.015-inch thick, 1.20 per cent carbon steel metallized surface in the press fit proved to be 50 per cent higher in fatigue resistance to breaking off in the wheel fit and 160 per cent greater in fatigue resistance to initiation of cracks.

Certain applications are encountered where metallizing alone satisfies both design and cost requirements. A good example of such a case is that of a heavy boring shaft arranged to slide within a driver sleeve, a key in the sleeve

operating in a long keyway in the shaft, *Fig.* 7. Although a combination of metals such as SAE 52100 hardened and ground steel for the sleeve and turned, ground and nitrided nitralloy steel for the shaft could be used, it was found most expedient and economical to provide merely an ordinary easily machined steel sleeve (SAE 1020) and a shaft of similar material metallized with bronze. The sprayed bronze coating on the shaft not only simplified manufacture but also made possible "oil-less" lubrication, a quality not possible otherwise. Keyways for such jobs should be specified as shown in the shaft cross-section.

Wide Variety of Metals Available

MATERIALS: Practically every metal available in wire form, except perhaps tungsten, can be sprayed in a wire gun—brass, bronze, copper silicon-bronze, aluminum-bronze, aluminum, magnesium, lead, tin, iron, zinc, cadmium, babbitt, nickel, carbon and alloy steels, monel, stainless, Stellite alloys, molybdenum, tantalum, nichrome, etc. High melting point alloys, especially those available only in powder form such as those for hard facing, are readily handled by spray welding. In addition to materials suitable for powder gun spraying mentioned previously, mixtures such as powdered glass and metal can be utilized where increased bond strength and a nonporous coat are desired. Deposit efficiency is best for the wire gun and ranges from around 65 per cent for easily oxidized metals such as zinc to 90 per cent for aluminum, iron and steel.

Sprayed zinc and aluminum coatings for protection of ferrous metals are usually from 0.004 to 0.010-inch in thickness depending upon severity of conditions. Coatings of tin and lead run 0.010 to 0.020-inch while nickel coatings are usually a little greater. The wire method provides a superior quality of metallic coating for such corrosion resistance purposes.

TOLERANCES: Except in the case of protective coatings where reasonable uniformity in thickness is imperative, sprayed metal surfaces are always finished by one of the common methods—turning, milling, grinding, etc.,—and consequently coating wall thickness may vary considerably. Finished tolerances available, therefore, depend primarily upon the finishing method or methods employed.

The peculiar structure of sprayed metals—excepting those spray welded of course—makes machining sometimes a problem. Particular care is necessary to avoid "picking out" particles and creating a poor surface in finishing machinable sprayed metals. Likewise, in dry grinding, special care in selection of wheels and speeds is necessary to assure satisfactory surface finish. Where high accuracy and critical tolerances on surface finish are demanded, wet grinding after rough machining can be employed with highly satisfactory results.

Collaboration of the following organizations in the preparation of this article is acknowledged with much appreciation:
Bridgeport Brass Co. ..... Bridgeport, Conn.
General Electric Co. (*Figs.* 2 and 6) .... Schenectady, N. Y.
Glenn L. Martin Co. (*Figs.* 1 and 4) ..... Baltimore
Metallizing Engineering Co., Inc. (*Fig.* 3) .....
..... Long Island City, N. Y.
John Nooter Boiler Works Co. (*Fig.* 6) ..... St. Louis Mo.
Wright Aeronautical Corp. (*Fig.* 5) ..... Paterson, N. J.

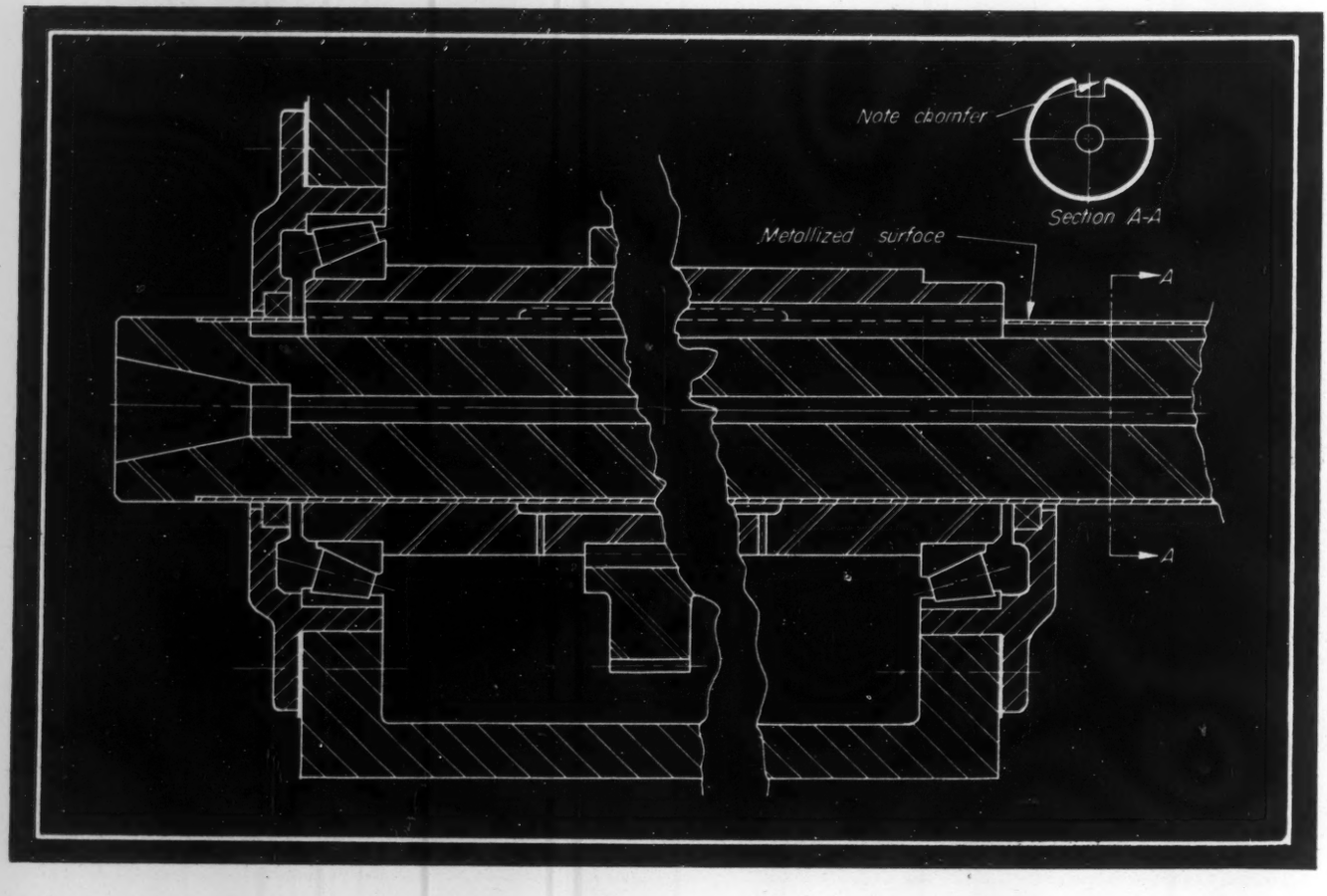
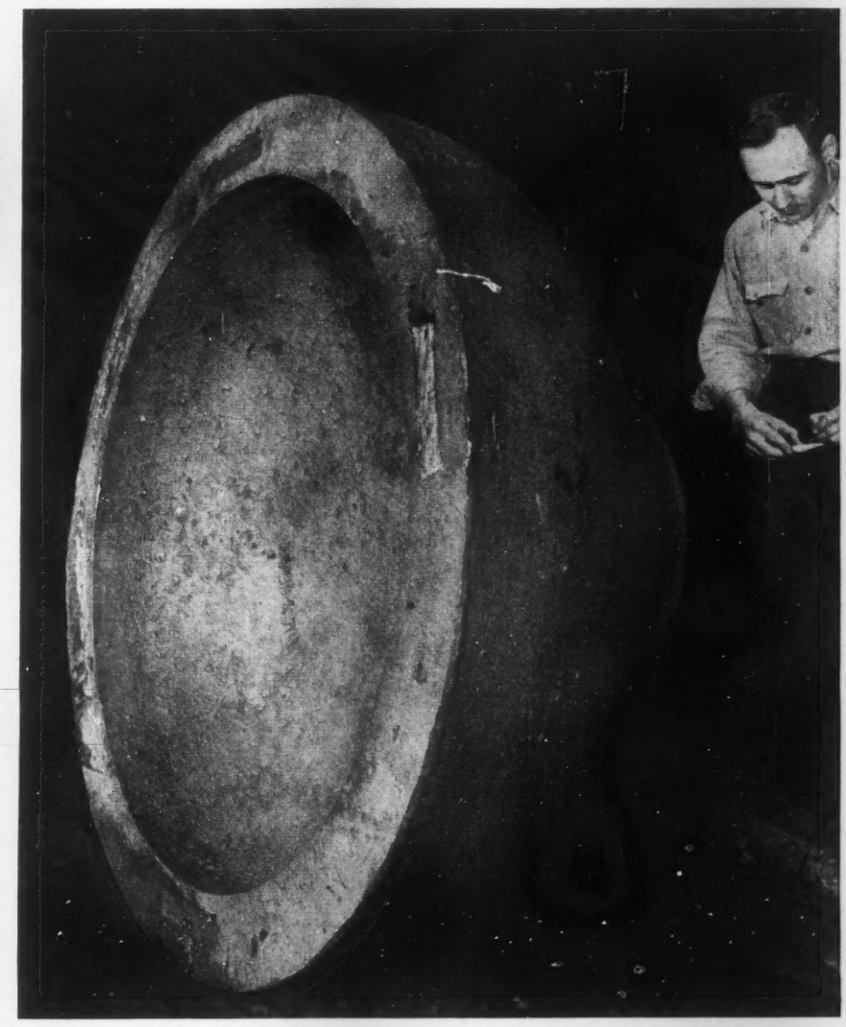


Fig. 7—Sliding boring shaft, metallized with bronze, reduces cost considerably and guarantees self lubrication

WHICH CAST STEEL?



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PART II—Commercially Available Cast Steels

IT WAS indicated in the first article of this series that a full range of physical properties is available for the economic utilization of steel castings. As a guide for computations, the designer must have available the minimum physical properties of commercially available cast steels.

Since the steel foundries accept the standards of the recognized specification writing bodies, these specifications become, in effect, the commercially available cast steels. The use of standard specifications assures the designer that various sources of steel castings will have in production the necessary compositions and heat treating techniques to provide prompt delivery and reliable quality.

Specifications of the American Society for Testing Materials (ASTM) and those of the Society of Automotive Engineers (SAE) are most applicable to general machine parts. The specifications of the ASTM are the oldest and most widely used. The SAE steel specifications have been issued only recently but contain certain provisions which are particularly useful for certain design demands. Both specifications are either new or have been revised within the last year and include the latest improvements available in physical property specifications as well as inspection methods.

For general machine elements, the two applicable ASTM specifications contain the properties compiled in TABLE I. The specifications are: ASTM A27-46T Mild to Medium Strength Carbon Cast Steel; and ASTM A148-46T Tenta-

Fig. 7—Above—Since this casting is subjected to high pressures, tensile test is required in specification

TABLE I

Recommended ASTM Specifications for General Machine Elements

ASTM A27-46T: Tentative Specification for Mild to Medium-Strength Carbon-Steel Castings for General Application

Grade Number	Tensile Requirements: Tensile Strength (min. psi)	Yield Point (min. psi)	Elong. in 2 Inches (min. %)	Reduction in Area (min. %)	Heat Treatment*	Chemical Composition Requirements: Carbon** (max. %)	Manganese** (max. %)	Silicon (max. %)	Sulphur (max. %)	Phosphorus (max. %)
N-1	....	....	....	....	None Req'd	0.25	0.75	0.60	0.06	0.05
N-2	....	....	....	....	Required	0.35	0.60	0.60	0.06	0.05
N-3	....	....	....	....	Required	....	1.00	....	0.06	0.05
U-60-30	60,000	30,000	22	30	None Req'd	0.25	0.75	0.60	0.06	0.05
60-30	60,000	30,000	24	35	Required	0.30	0.60	0.60	0.06	0.05
65-30	65,000	30,000	20	30	Required	....	....	....	0.06	0.05
65-35	65,000	35,000	24	35	Required	0.30	0.70	0.60	0.06	0.05
70-36	70,000	36,000	22	30	Required	0.35	0.70	0.60	0.06	0.05

ASTM A148-46T: Tentative Specification for High-Strength Steel Castings for Structural Purposes

80-40	80,000	40,000	18	30	Required	No chemical requirements except: Sulphur—0.06 max per cent, Phosphorus—0.05 max per cent.
80-50	80,000	50,000	22	35	Required	
90-60	90,000	60,000	20	40	Required	
105-85	105,000	85,000	17	35	Required	
120-100	120,000	100,000	14	30	Required	
150-125	150,000	125,000	9	22	Required	
175-145	175,000	145,000	6	12	Required	

*All castings requiring heat treatment shall be treated either by full annealing, normalizing, normalizing and tempering, or quenching and tempering.

**0.04 per cent manganese increase above maximum permitted for each reduction of 0.01 per cent carbon below the maximum specified; limited to 1.00 per cent maximum manganese content.

tive Specifications for High-Strength Steel Castings for Structural Purposes.

ASTM SPECIFICATION A27-46T: Applies to carbon steel castings ranging in minimum tensile strength between 60,000 and 70,000 psi, and minimum yield points between 30,000 and 36,000 psi. Except for grades N-3 and 65-30, all are suitable for welding.

Grade N-1: This grade is not required to be either heat treated or tensile tested. Commercial practice with the specified chemical composition limitations will result in an expected tensile strength between 60,000 and 75,000 psi and a yield point between 35,000 and 45,000 psi.

Grade N-1 castings seldom are used for machine elements except for brackets, handles, bases and similar parts very lightly stressed. This grade can be used when castings are well designed and fairly simple in shape with the stress pattern of service loads having been determined by actual field performance. Usual machine elements are of varying shapes and sections with the probability that high "internal" or "locked-up" stresses will exist in an untreated casting. The probability of high internal stresses eliminates the use of this grade for machine elements requiring high dimensional stability or other than low service requirements for stress or toughness.

Grade N-2: This grade requires no tensile tests and allows a 0.35 per cent maximum carbon content. Usual heat treatment applied in the foundry is annealing (furnace cooling) or normalizing (air cooling). The properties will be similar to annealed SAE 1030 bar stock material. Tensile strength will vary between 60,000 and 80,000 psi and the yield point between 30,000 and 45,000 psi. The higher values will be obtained with a carbon content near the upper limit and section thicknesses under one inch. For design calculations, a minimum tensile strength of 60,000 psi and a minimum yield of 30,000 psi can be used. Grade N-2 is widely used for cast steel machine elements requiring welding and where the expense of testing is not justified. It offers a good balance between strength and weldability.

Grade N-3: This grade is similar to N-2 in that no testing is required. The difference is that no carbon limitations are specified in Grade N-3. The absence of a carbon limitation enables the foundry to use a greater range of heats resulting in the probability of prompter delivery. Usual commercial heat treatment is an anneal or normalize.

Ordinarily, the expected tensile properties will be similar to those secured with Grade N-2 and the same minimum physicals can be used for design purposes. As a general rule for machine elements not requiring tensile tests, Grade N-2 is specified when welding operations are required on the steel casting and Grade N-3 is used when no welding operations are involved.

Grade U-60-30: Identical to grade N-1 in expected tensile properties and chemical composition. It is expected to be used in the "as cast" condition, the only difference being the necessity of conducting tensile tests. Since tensile tests from coupons produce no indications of the "internal stress" magnitude or properties in the "as cast" section, grade U-60-30 is not recommended for general machine elements.

Grade 60-30: Used where the designer requires a tensile test for assurance that the properties are as specified. This grade is particularly for use when welding operations are applied to the casting. The tensile strength usually will vary between 60,000 and 75,000 psi with the yield point varying from 30,000 to 47,000 psi.

Grade 65-30: Absence of a carbon content limits this grade to castings on which no welding is involved. It is used when stresses are sufficiently high to warrant a tensile test. The tensile properties can be expected to range between 65,000 and 80,000 psi and the yield point between 35,000 and 45,000 psi.

Grade 65-35: This grade is similar to the 60-30 grade except for the higher tensile strength and yield point.

Grade 70-36: Provides the highest minimum physical properties for this specification. Usually, the tensile strength will vary between 70,000 psi and 85,000 psi and the yield point from 36,000 to 50,000 psi. The upper values will be secured on light sections (under 1 inch).

Comments on ASTM A27-46T

From the discussion presented, it is apparent that there are too many minor variations between grades to warrant the adoption of all grades in any particular design activity. The various grades were introduced into the ASTM specifications to meet consumer demands for special-purpose castings. The writer would recommend a selection based on TABLE II as being appropriate to cover the needs of the designer. The majority of machine elements can be standardized on grades N-2 and N-3.

Castings for machine elements are ordered to tensile tests only for meeting special codes or where the stresses are unusually high and assurance that the metal conforms to the specified minimum properties is absolutely required and when the additional testing expense is warranted.

For example, the cast steel bearing supports shown in *Fig.* 8 are joined with plates to form a base for a gear reduction unit. The primary requisites are rigidity and weldability. The material is specified by ASTM A27-46T, Grade N-2 which does not require tensile tests.

The steel casting illustrated in *Fig.* 7 is subjected to

high pressures and a tensile test would logically be required. The specifications would be ASTM A27-46T, Grades 60-30, 65-35 or 70-36 depending upon the stresses.

Characteristics of the steels supplied to this specification are such that the tensile test properties obtained on test coupons will be representative of the properties secured in the casting. Even for heavy sections greater than the test coupon sections, the margin usually secured above the minimums specified requires no design calculation adjustments to compensate for section size.

This specification allows a variety of heat treatments to be used to obtain the physicals. It is the practice of many machine designers definitely to demand a slow furnace cool upon the supposition that greater toughness and dimensional stability will be obtained. At times, a low-temperature limit is set, above which the castings are not to be exposed to the air or pulled out of the furnace. Such restrictions are definitely obsolete and actually harmful to the expected properties. As was shown in the first article of this series, the faster the cooling rate the better the toughness, impact strength and yield-point/tensile-strength (YP/TS) ratio. Definitely specifying a slow furnace anneal is the same as requesting a poor combination of properties, which, obviously, is technically unsound.

Welding Requires Caution

Steels normally supplied to meet ASTM A27-46T specifications are commercially considered as weldable. However, the term "weldable" as related to steel castings does not imply that no special precautions need be taken in welding any or all shapes of steel castings. Regardless of composition, the welding of any steel part of intricate shape or cross section might necessitate a more careful welding technique than would be utilized for parts of a reasonably simple or symmetrical shape. To promote maximum weldability, the specification includes provisions for limiting the unspecified alloying elements which are always found in steel. For carbon and alloy grades of steel castings having strengths in excess of 70,000 psi, the designer can utilize ASTM Specification A148-46T.

ASTM SPECIFICATION A148-46T: This specification, TABLE I, presents an orderly arrangement of grades ranging from 80,000 psi to 175,000 psi tensile strength. No limitations are placed upon the chemical composition except maximum contents for sulphur and phosphorus. The numerical designation of the grades represents the tensile and yield strengths. Grade 80-40 represents 80,000 psi minimum tensile strength and 40,000 psi minimum yield strength, while Grade 150-125 represents 150,000 psi minimum tensile strength and 125,000 psi minimum yield point.

Expected Tensile Properties: A comparison of the tensile and yield strengths specified in ASTM A148-46T with those in Fig. 2 of the first article in this series indicates that the YP/TS ratios used in the specification are representative of expected results. It can be concluded, therefore, that the spcification allows for efficient utilization of the material for each grade.

For all grades the tensile properties secured by an annealing or normalizing treatment will vary from the specification minimum to approximately 10,000 psi higher, and those obtained by quenching or tempering will vary from the minimum to 20,000 psi higher for the low-strength grade to 10,000 psi higher for the highest-strength grade.

Properties of Grade 80-40 easily can be secured by either annealing (furnace cooling) or normalizing (air cooling). Grade 80-50 usually requires a normalizing treatment with alloys added for heavier sections. Grade 90-60 requires alloying for a normalizing treatment although the physicals can be secured in a straight carbon steel by liquid quenching if the section is not too great. Grade 105-85 requires alloying if it is to be obtained by a simple normalizing and tempering treatment, particularly if a good balance between strength and toughness is desired.

Grades 120-100, 150-125 and 175-145 are recommended for use in the quenched and tempered condition since this treatment will produce the optimum strength-toughness relationships. However, the latter grades can be met by a simple normalizing and tempering treatment at the expense of considerable alloy additions. Also, the resulting impact resistance and YP/TS ratio will be low.

These comments are of use to the designer inasmuch as large or intricately shaped castings involve the hazards of cracking or excessive distortion during liquid quenching. For such designs, preliminary calculations should be based upon grades whose physicals can be obtained by the less severe heat treatments such as annealing, normalizing or normalizing and tempering, unless the increased expense of high alloying is justified to obtain higher properties by annealing or normalizing. Recognition must be given to the fact that size and intricacy are relative terms based upon the facilities available in the individual foundry. To determine the proper category, the designer must be familiar with the probable sources of the steel casting being designed.

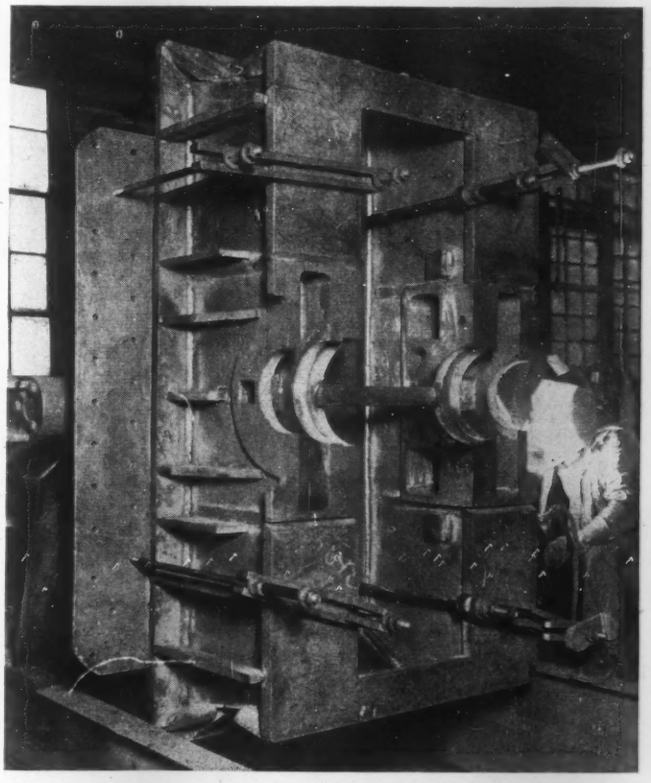

Fig. 8—Key requirements of this bearing support are rigidity and weldability. Tensile testing is not required

Cognizance must be given to the fact that the tensile tests for this specification are obtained from coupons 1-inch to 1¼-inch square. Since the tensile properties for heat-treated steels are dependent upon the response to heat treatment and penetration thereof—which actually reflects the size of section—a degree of precaution must be taken to determine that the test bar reflects the physicals secured in the critically stressed section of the casting.

As an example, *Fig.* 9 shows the hardness gradient which exists in 1, 2 and 4-inch sections (rounds) for a straight carbon steel and a chrome-moly alloy steel water-quenched and tempered at 1100 F.

A satisfactory correlation between test coupons and ac-

TABLE II

Recommended ASTM A27-46T Grades for Machine Elements

Type	Welding Required	Welding Not Required
Untested Castings Tensile Tested	N-2 60-30, 65-35, 70-36	N-3 65-30, 70-36

tual castings exists for all grades in sections under 1½ inches thick, for grades 120-100 and lower in sections under 2½ inches thick, and for grades 90-60 and lower in sections under 4 inches thick. For the particular grades having sections greater than these, it appears desirable to discuss the problem with the foundry to insure that satisfactory response to heat treatment will be obtained for the service loading or design stresses.

Limitations of ASTM Specifications

Although the specifications A27-46T and A148-46T are satisfactory for the majority of applications, the machine designer sometimes is confronted with special problems for which these specifications are not adequate.

For example, no grade is provided for steels satisfactory for carburizing purposes. No provisions are made for checks on the individual castings for proper heat treatment. This many times is provided by a simple brinell hardness reading at the critically stressed portion of the casting. There are certain applications where limitations are desired on the chemical composition in the interests of shop production such as machinability or on carbon content for parts to be flame or induction hardened, or required to resist abrasion. Also, parts to be treated in the purchaser's plant cannot be precisely specified by appropriate ASTM specifications.

In many instances when the ASTM specifications cover substantially the desired properties, specific agreements between the purchaser and foundry can be made to produce the desired results adequately. Since the automotive and allied industries constantly encounter these problems, a newly drafted SAE Tentative Standard has been developed for Automotive Steel Castings. The SAE standard has been released only recently and to date has not been widely used by the steel foundry industry; nevertheless, there are certain features which might make their use by the designer appropriate.

The SAE steel castings specifications, tabulated in TABLES III and IV, classify the following groups:

(a) Plain carbon steels specified by chemical composition and minimum tensile properties (except for the carburizing grade which is based on chemical composition only)

(b) High-strength steels specified by minimum tensile properties, for miscellaneous uses where the requirements do not justify hardenability control

(c) High-strength steels specified by minimum tensile properties and hardenability requirements.

All plain carbon steels specified by chemistry carry a prefix of 00 followed by the first two figures of the maximum carbon content. All high-strength steels specified by tensile properties carry a prefix of 0 followed by the figures expressing the minimum tensile strength in thousands of pounds. All high-strength steels specified by tensile properties and hardenability carry a prefix 0 followed by the figures expressing the minimum tensile

TABLE III

Grades of Steels and Requirements; Plain Carbon and Low-Alloy Cast Steel

SAE Grade	Description	Chemical Analyses C	Mn	Si	P	S	Residual Alloy Limitations	Tensile Properties (minimum)[3] T.S. (psi)	Y.P. (psi)	Elong. in 2 in. (%)	R.A. (%)	B.H.[4] No.	Heat[5] Treatment
0022	Low - carbon cast steel suitable for carburizing	0.12-0.22	0.60 max[1]	0.60 max	0.05 max	0.06 max	Residual alloys shall be limited by maximum core hardness required subject to specified agreement between producer and purchaser in inquiry and order.	Not Required					A or N or N-T
0030	General - purpose cast steel; welding grade	0.30 max	0.70 max[1]	0.60 max	0.05 max	0.06 max	See Note [2]	65,000	35,000	24	35	131	A or N or N-T or Q-T
0050	Medium-high-carbon cast steel suitable for castings requiring high surface hardness	0.40-0.50	0.50-0.90	0.20-0.60	0.05 max	0.06 max	To be specified by max hardenability values when residual alloy limitations are required subject to specific agreement between producer and purchaser in inquiry and order.	85,000 100,000	45,000 70,000	16 10	24 15	170 207	N or N-T Q-T
080	Carbon or alloy cast steel (usually of lower C content than Type 0050	Not Required			0.05 max	0.06 max		80,000	40,000	18	30	163	A or N or N-T or Q-T
090	Alloy cast steel	Not Required			0.05 max	0.06 max		90,000	60,000	20	40	187	N-T or N-Q-T

[1] For each reduction of 0.01 per cent carbon below the maximum specified, an increase of 0.04 per cent manganese above the maximum specified will be permitted to a maximum of 1.00 per cent manganese.

[2] Residual alloys, the determination of which shall be a matter of agreement between the manufacturer and purchaser, shall not exceed the following limits: Copper, 0.50 maximum; nickel, 0.50 maximum; chromium plus molybdenum, 0.25 maximum; tungsten, 0.10 maximum; total content of these unspecified elements, 1.00 maximum. For each 0.1 per cent below this specified maximum alloy content of 1.00 per cent an increase of 0.02 per cent chromium plus molybdenum content and 0.06 per cent nickel and copper content above the specified maximum will be permitted. No change is recommended on the other chemistry or the carbon-manganese relationship.

[3] These values to be obtained from coupons of 1 to 1¼-inch cross section. Tempering temperatures for the castings to be adjusted for the required brinell hardness to compensate for variations of mass between casting and test bar.

[4] These values are applicable to casting sections not over 3 inches. (Brinell hardness values to be secured on castings only.)

[5] A—Anneal, N—Normalize, N-T—Normalize and Temper, Q-T-Quench and Temper.

TABLE IV

High-Strength Steel Castings for Structural Purposes

SAE Grade	Description	Chemical Analysis C	Mn	Si	P	S	Hardenability Factor H	Tensile Properties (minimum)[3] T.S. (psi)	Y.P. (psi)	Elong. in 2 in. (%)	R.A. (%)	B.H.[1] No.	Heat[2] Treatment
0105	Alloy Cast Steel	Not Required			0.05 max	0.06 max	Consult Table V for H values	105,000	85,000	17	35	217	N-Q-T
0120	Alloy Cast Steel	Not Required			0.05 max	0.06 max	Consult Table V for H values	120,000	100,000	14	30	248	N-Q-T
0150	Alloy Cast Steel	Not Required			0.05 max	0.06 max	Consult Table V for H values	150,000	125,000	9	22	311	N-Q-T
0175	Alloy Cast Steel	Not Required			0.05 max	0.06 max	Consult Table V for H values	175,000	145,000	6	12	363	N-Q-T

[1] These values are applicable to casting sections not over 3 inches.
[2] N-Q-T—Normalize, quench and temper.
[3] These values to be obtained from coupons of 1 to 1¼-inch cross sections. Tempering temperatures for the castings to be adjusted for the equivalent brinell hardness.

strength in thousands of pounds and a suffix H with a number and letter attached corresponding to the hardenability factor.

SAE Plain Carbon and Low-Alloy Cast Steel

SAE Grade 0022: This is low-carbon carburizing grade satisfactory for general case-hardening purposes.

Grade 0030: This grade is similar to ASTM A27-46T Grade 65-35 and the remarks previously made apply.

Grade 0050: Equivalent to the popularly used rolled or forged carbon Grade SAE 1045. This grade has considerable application in the general machine design field because of its high strength, low cost and ability to be surface hardened by the flame or induction-hardening systems. Recognition must be given to the fact that this grade is not readily weldable either for repair or assembly.

Grade 080: Identical to ASTM A148-46T Grade 80-40. The carbon content usually can be expected to be lower than Grade 0050 and within the commercially expected range of 0.25 to 0.40 per cent carbon. The absence of chemistry limits on carbon usually will facilitate foundry production as previously mentioned.

Grade 090: Identical to ASTM A148-46T Grade 90-60 except that the steel must be normalized, or normalized, quenched and tempered.

SAE HIGH-STRENGTH STEEL CASTINGS FOR STRUCTURAL PURPOSES: The grades included under this specification have tensile properties identical to those of ASTM A148-46T except that heat treatment is limited to a quench and temper. An additional provision is made that the steel can be ordered to hardenability limits which will assure a steel having a desired response and penetration to heat treatment. In view of the limited experience with the application of hardenability qualifications to steel castings, this provision is explicitly designated as tentative. It is recommended that any machine designer approaching the problem of hardenability qualifications proceed cautiously and have a complete understanding with the producer.

HARDENABILITY AND SELECTION OF HARDENABILITY FACTORS: The SAE specification illustrates by examples the approach to the selection of a proper hardenability qualification. Selection of the particular class is obtained from the data presented in TABLES IV, V and VI. As an example, a steel casting of 2-inch critical section thickness is subjected to tensile stresses and is required to meet a minimum of 105,000 psi tensile strength. The casting is to be given an agitated water quench to obtain the required properties.

As this casting will be stressed in tension, it is desirable to produce full quench hardness throughout the critical section thickness. Referring to TABLE V, the agitated water quench for hardening to the center is a type C treatment and the class for a 2-inch thickness is class H-4. The specification would therefore be "SAE-105-H-4C". The equivalent Jominy or "end-quench" distance corresponding to type C heat treatment and H-4 thickness is 11 (sixteenths of an inch).

If the casting were to be subjected to a bending stress

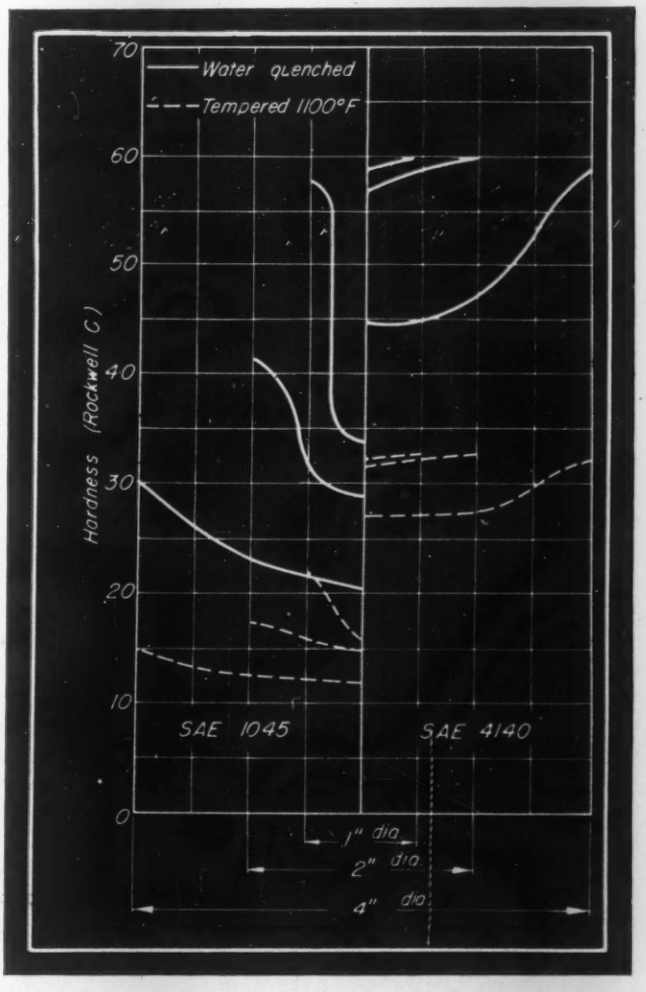

Fig. 9—Hardness gradients through 1, 2 and 4-inch rounds of straight carbon steel and chrome-moly alloy steel

TABLE V

Hardenability Selection—SAE Steel Castings Specifications

Type	Quenching Treatment	Depth of Full Response to Heat Treatment	Equivalent Jominy Distance in Sixteenths — Class and Thickness*				
			H1 ½″	H2 1″	H3 1½″	H4 2″	H5 2½″
A	Agitated Water Quench	⅛ of critical section thickness	1½	2½	3½	4½	5½
B	Agitated Water Quench	¼ of critical section thickness	2	4	6	8	10
C	Agitated Water Quench	Center of critical section thickness	3	5	8	11	14
D	Agitated Oil Quench	Center of critical section thickness	4	8	11	14	18

*Plate section thickness.

wherein the stress diminishes to the center, a full hardening steel might not be required. For example, with response to heat treatment required to ¼ of the section thickness, the specification would read "SAE 105-H-4B." It is to be noted that the thicknesses given are for plate sections. If rounds are involved, the equivalent Jominy distance must be corrected accordingly. If a more complicated section is involved, such as occurs in hollow castings or when adjacent sections are considerably different in size, a metallurgical test is required to determine the actual equivalent Jominy distance.

The most important selection factor is the determination of the proper depth of the cross section desired to be hardened (80 per cent martensite). The selection entails considerable metallurgical interpretation. For example, to obtain maximum impact resistance, toughness and highest YP/TS ratio, the desired quench hardness should be to the center of the section if the material is stressed throughout its section as in tensile loading. Modifying this concept are some indications that deep hardening steels produce high internal stresses which might substantially alter the service theoretically expected. In addition, the hazards of cracking during heat treatment are likely to increase with greater hardenability.

These examples and discussion on hardenability are not made for the purpose of giving the designer a working knowledge for the proper selection of hardenability. Rather it is to emphasize the fact that a selection from the SAE specification must be given adequate design as well as metallurgical study. Because of these many complications, the designer should not be apprehensive about approaching the problem of hardenability, but should seek competent metallurgical advice.

In general, it would appear that the hardenability qualification has its greatest use for the plant which expects to do its own heat treating or for the machine element which must be designed to obtain the absolute maximum from the material either for economic reasons, as in the high-production automotive field, or where the same objective must be secured for technical reasons such as to reduce inertia forces by weight reduction, conservation of space, etc. In fact, the designation of a hardenability qualification might be necessary purely for production reasons. For example, a steel casting with a 4-inch round section and a 1-inch round section might require a hardness of 24-28 rockwell C (248-269 brinell) on the 4-inch diameter with the loading requiring very little penetration. If a low-hardenability steel were selected, as would logically be expected, the hardness on the 1-inch section might be 40-42 rockwell C (375-401 brinell). This high hardness would cause production problems if precision or intricate machining were necessary on the small section. Increasing the hardenability of the steel tends to minimize the hardness differential between light and heavy sections after quenching and tempering, and in the example can result in only a slight hardness difference between the 1-inch and 4-inch sections.

Of interest to the designer is an inclusion in the SAE specification for the hardness check on castings (not over 3 inches in section) and provisions for adjusting the tempering temperature of the actual castings to compensate for the difference in section between the 1-inch or 1¼-inch square test coupon and the size of the actual casting section. This procedure recognizes the difference that exists in response to heat treatment between section thickness as illustrated in *Fig.* 9. A provision is included in the specification which enables a reduced frequency of either tensile or hardness checks when mutually satisfactory to purchaser and producer.

OTHER PROVISIONS OF ASTM AND SAE SPECIFICATIONS: There are other provisions in these standard specifications which in some circumstances might be of interest to the designer. These relate to quality inspection methods.

Radiographic Inspection: In certain machine elements there exists a need for radiographic and magnetic particle testing. Castings subjected to high pressures and high temperatures when severely stressed might logically be radiographed when a hazard to property or life exists in the event of failure.

It must be recognized that an absolutely sound casting radiographically is different from a commercially sound casting. For example, a commercially manufactured casting of a design having a long thin member might, at the

TABLE VI

Minimum As-Quenched Hardness at Selected Jominy Distance for Foundry Control

(based upon approx. 80 per cent martensite)

Carbon Content (per cent)	Minimum Hardness (Rockwell C)
0.20	36
0.25	39
0.30	42
0.35	45
0.40	48
0.45	50

center of the section, have some segregation and perhaps microscopic voids which would not affect service performance and might not even be visually apparent on a ground surface of a cross section. Yet, a radiographic inspection will record this condition. Considerable extra production costs are necessary to make a long thin member absolutely radiographically homogenous.

To the designer, a specification involving radiographic examination means that an extra expense might be involved over and beyond the cost of merely making a radiographic exposure. Such additional cost might increase the price 15 to 30 per cent plus the expenses involved in radiographing. To minimize the cost of radiographic inspection, the designer should advise the foundry of the exact areas required to be radiographically sound, the frequency of examination and particularly the standards to be used for acceptance or rejection.

The Radiographic Standards for Steel Castings (July 1, 1942) Bureau of Ships, Navy Department, Washington, D. C., are recommended as a basis until commercial ASTM specifications are released. These standards are comparative and, depending upon service conditions, selections can be made for determining when a casting must be rejected, when a casting can be repaired, and when a casting is acceptable without repair.

Magnetic Particle Inspection: The magnetic particle type of inspection (commonly referred to as Magnaflux inspection) is perhaps of more importance to the machine designer than radiographic inspection because surface cracks and discontinuities which act as points of stress concentration (stress raisers) so harmful to fatigue life and impact can be detected. Standard ASTM Specification A272 applies to Tentative Methods of Magnetic Particle Testing and Inspection of Commercial Steel Castings. Unfortunately, this specification covers only the test procedure. The designer must decide the standards of acceptability. Literature of war production experience indicates that not every magnetic particle indication is harmful. The designer must designate the areas to be inspected as well as the frequency of inspection. If no standards are available, the foundry should be advised of the service requirements and a satisfactory economic magnetic particle standard usually can be set for the casting.

Destructive Tests: Tests to destruction sometimes are specified. The mere sectioning or fracturing of a casting to reveal possible internal defects is of little importance to the designer. A standardized tension, compression or simulated service load on full scale castings is superior, particularly if the interpretation is based upon experience with similar castings which will reflect the quality of the casting rather than the design. Recognition must be given the fact that service life, particularly fatigue, follows a mortality curve and the standards must be based upon a sufficient number of tests to obtain the characteristics of the mortality curve of the particular casting subjected to carefully controlled conditions of test loading.

CHEMICAL COMPOSITION SPECIFICATIONS: As indicated previously, the standard specifications do not involve chemical composition unless they affect welding or heat-treating characteristics. This is a correct specification procedure since the tensile characteristics of structural steels having the same tensile strength or hardness for a given heat treatment are identical regardless of the chemical composition. Also, the foundry produces a finished article which, unlike a steel mill product, cannot be diverted into another finished product if the chemical composition is "off analysis"; hence the standardized procedure of minimizing chemical composition limits, which also usually results in more prompt delivery. However, the steel foundry, since it produces smaller heats, is in an ideal position to melt "custom" heats if a design requires a special chemical analysis.

TABLE VII

Recommended Basic-Design Minimum Tensile Properties and Specifications for Commercial Steel Castings

Tensile Str. (min, psi)	Yield Str. (min, psi)	Applicable Specifications ASTM	SAE
		A27-46T	
60,000	30,000	N-2, N-3, 60-30	
65,000	30,000	Grade 65-30	
65,000	35,000	Grade 65-35	
65,000	35,000		Grade 0030
70,000	36,000	Grade 70-36	
		A148-46T	
80,000	40,000	Grade 80-40	Grade 080
80,000	50,000	Grade 80-50	....
85,000	45,000	....	Grade 0050
90,000	60,000	Grade 90-60	Grade 090
100,000	70,000	....	Grade 0050
105,000	85,000	Grade 105-85	Grade 0105
120,000	100,000	Grade 120-100	Grade 0120
150,000	125,000	Grade 150-125	Grade 0150
175,000	145,000	Grade 175-145	Grade 0175
Weldable Grades		A27-46T	
60-70,000	30-36,000	N-2, 60-30, 65-35, 70-36	Grade 0030
Carburizing Grade		None	Grade 0022
Surface-Hardening Types Carbon Steel High Strength		A27-46T Grades N-2, 70-36 A148-46T	Grade 0050 SAE High-Strength Steel Castings
Hardenability Qualifications		....	0105 to 0175 incl.
Hardness Specifications		....	All Grades Except Grade 0022

CONCLUSION: The first article of this series indicated that a full range of properties is available in steel castings. This article has shown that standard specifications are available setting minimum properties for various grades which the designer can use, with appropriate factors-of-safety, for basic design calculations. These standard properties are obtainable from commercially available cast steels. The standard specifications are sufficiently versatile to enable more restrictive testing and quality inspections to be used for the most exacting design and service requirements. In summary, the outline in TABLE VII might be useful for selecting grades of cast steel.

Next article of this series will include an outline indicating the information required by the foundry to successfully manufacture the casting in order to obtain proper quality and service. Included will be hints affecting the economic considerations involved in ordering and specifying, production details which affect such processing as welding and machining, trade customs, and the perspective required to correlate improvements from the design to field service.

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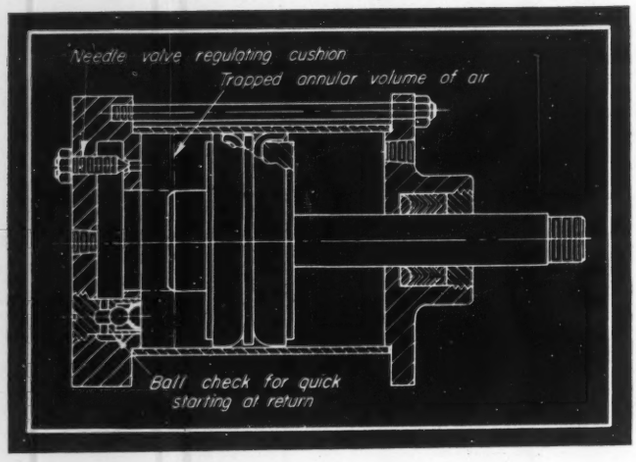


Fig. 1—Typical cylinder with an air cushion and bleed valve at head end

Air Cylinders

How to cushion their action and control their speed

BECAUSE an air cylinder provides closely-controlled force independent of piston position and is simple and reliable in construction, it is often a highly satisfactory power source for clamping, positioning, shearing, and other reciprocating machine motions. Costs are usually low, especially where compressed air is available. The elasticity of compressed air can be a serious drawback, however, particularly on strokes of two or more inches where pounding and irregular, jumpy action become problems that must be overcome by careful design and equipment selection.

Specification of built-in cylinder cushions may be adequate in a shear drive, for instance, but special attention is required to gain smoothness in an index in which the air cylinder must overcome a high load during the first or middle portion of the stroke. Unless a hydraulic dash-pot is added, the indexed mass may leap uncontrollably to the end of the stroke once the load peak is overcome, because of the high pressure built up within the cylinder in overcoming this peak.

This article considers a number of the many methods of piston cushioning and speed control applicable to air cylinders. Some of these devices may be found useful in making an inexpensive correction of an improper original equipment selection, and others offer means to the designer for avoiding the initial expense of a hydraulic pump installation where equivalent results can be accomplished with air. It must be emphasized that air is not represented as an answer to all reciprocating power problems, but only as a clean, low-cost motive source useful where precise position or speed control is not necessary and where forces up to several tons are adequate. When a multiplicity of controlled-speed cylinders are required, installation of a hydraulic pump may be justified, particularly in view of the compactness characteristic of hydraulic power.

CUSHIONED AIR CYLINDERS: Jumping of a piston may not be objectionable if impact can be avoided at the end of its stroke. This may be accomplished by specifying the cushion-type air cylinder which is so constructed as to trap an air pocket ahead of the piston near the end of the stroke. The resultant slowdown action is regulated by permitting the air to escape through preset internal clearances or orifices. A typical cushion design, illustrated in *Fig.* 1, has a conventional rod end with a cushioned head end. Either or both ends, however, may be cushioned. Unless the piston never travels full stroke, it is recommended that cushions be specified where the stroke exceeds two inches or speed exceeds 60 feet per minute.

Cushioning Action from Cam-Operated Valve

AUXILIARY VALVE CUSHIONING: Built-in cylinder-cushioning action can be duplicated at moderate expense by the bleed-valve arrangement seen in *Fig.* 2. A standard three-way bleed valve with a roller stem is actuated by a cam on the cylinder rod so as to interrupt the exhaust near the end of the stroke. A by-passing needle valve controls the degree of cushion; and in order to permit rapid start of the return stroke, it is combined with a ball check through the use of a conventional speed control valve *A*. Speed control valves *B* and *C* are added to limit speed through the rest of the cycle.

MECHANICAL AND EXTERNAL CUSHIONS: A simple method to stop pounding utilizes a neoprene plug fastened to the end of the piston. A metal spring may be used but is generally inadequate. If the spring is strong enough to overcome the inertia and driving forces of the cylinder, permitting the piston to come to rest easily, it is impossible for the air cylinder to complete its stroke. If the spring is sufficiently weak to permit stroke completion, most of the cushion action must be sacrificed. Another effective answer to this problem is a coupled pneumatic or hydraulic dash-pot. A simple commercial dash-pot which will be found useful for small cylinders, is the well-known check door-closer.

SPEED CONTROL BY THROTTLING: One of the most common forms of speed control is hand throttling, typified by the pendant chain-operated throttling valve used in air hoists for manual control of load speed. Such an arrangement is simple and reasonably trouble-free. Safe control, however, is achieved only in the hands of a skilled operator. An up-down operating valve feeding through a preset needle valve is generally preferable where conditions permit.

The speed-control valve is a further refinement, permitting independent control of piston speed in each direction. As seen in *Fig.* 3*a*, a conventional speed-control valve consists of a needle valve combined with a check valve in one housing in such a manner as to give free air flow in one direction and throttled flow in the other. These valves are generally installed in pairs, one on each side of the air cylinder.

In general, the speed-control valve is a moderately effective speed regulator throughout the stroke unless the stroke load varies more than 100 per cent. In addition to speed control, a light cushioning action can be secured by throttling the cylinder exhaust and placing the valve as near as possible to the air cylinder. This will minimize the volume of the air pocketed at the end of the stroke, and thus secure quick pressure build-up should there be a tendency toward jumping. In some cases this method of cushioning may be adequate to ease a pounding cylinder.

Has Self-Cleaning Action

An objection has been noted to speed-control valves of the type shown in *Fig.* 3*a* on the ground that the needle orifice tends to plug with dirt when closely throttled. This objection can be overcome by fabricating the speed-control valve from a standard horizontal ball-check valve. As shown in *Fig.* 3*b*, a nut is brazed on the bottom of the valve housing under the ball seat and a screw is inserted to lift the ball a slight amount from its seat. A check nut is provided on the screw. This construction gives a natural self-cleaning action as the ball lifts during the return stroke. In addition to this helpful characteristic, the improvisation is extremely useful where a speed-control valve

Fig. 2—Right—Cam-operated bleed-valve arrangement provides controlled cushioning of piston movement

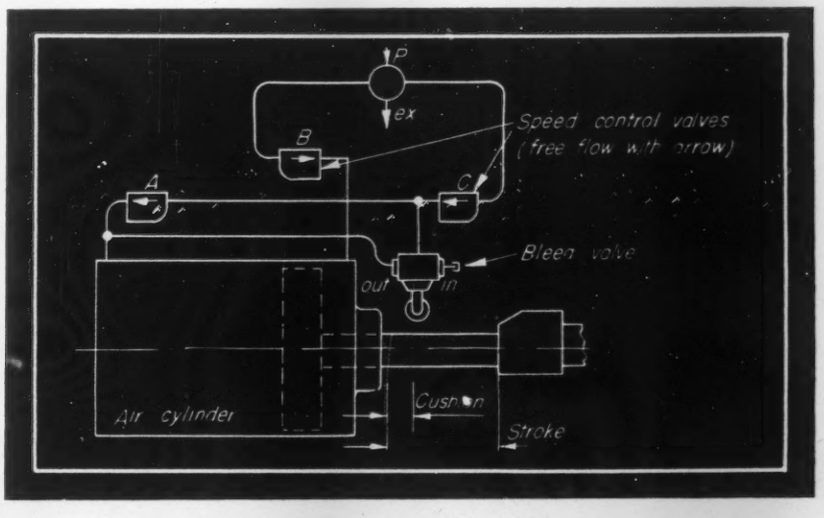
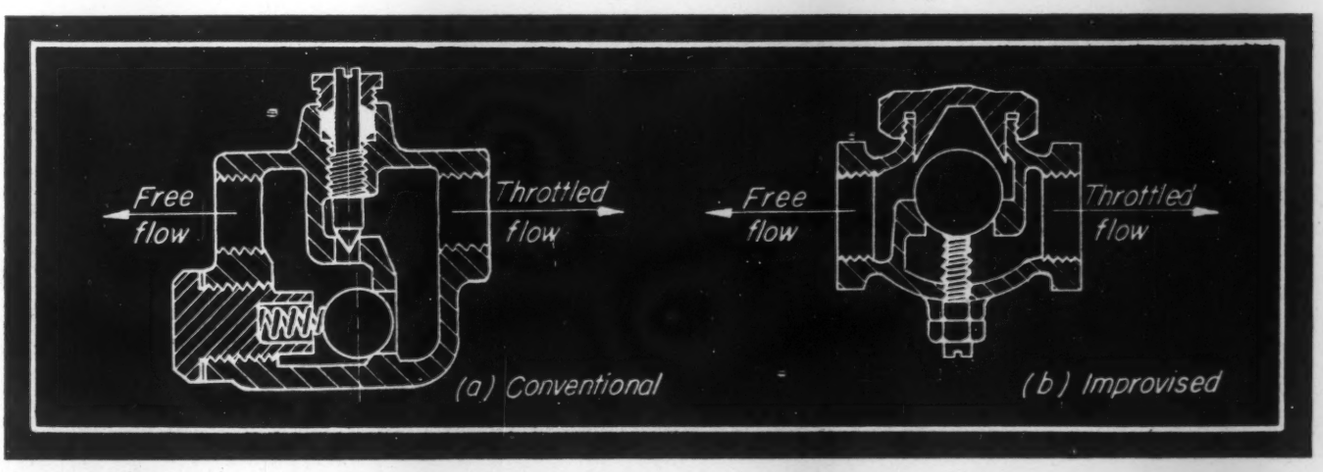


Fig. 3—Below—Speed-control valves having free flow in one direction and adjustable bleed in the other



is wanted for immediate installation and cannot be secured directly from the supplier's stocks. This principle is used by Schrader in their standard speed-control valve.

SUPPLEMENTAL DASH-POT FOR SPEED CONTROL: Precise control of speed equivalent to that obtainable with hydraulic power may be obtained throughout the stroke by coupling a supplemental oil-filled cylinder to the power cylinder. The oil in the dash-pot cylinder flows from one end to the other through an externally-connected needle valve or other orifice.

This system lends itself to a high degree of control. Speed may be varied by a variable-orifice valve operated by a cam fastened to the piston rod. If necessary, variation of speed with load, typical of all simple hydraulic cylinders, can be eliminated by use of special devices such as the Vickers constant-flow speed-control valve developed for hydraulic service. This valve adds a pressure-reducer ahead of the adjustable orifice in order to maintain a fixed pressure drop across the orifice.

Two cautions must be observed in the dash-pot design. Provision must be made for the change in volume as the piston rod enters and leaves the cylinder. Also, the pressures should be kept below 200 psi if air-cylinder type equipment is used, in order that the piston-rod packings will not be worn excessively and frequent oil additions be required. A drip pan and an automatic filling device are also advisable. *Fig.* 4 indicates how these basic elements can be assembled in an effective unit which also provides independent speed control in each direction.

This type of oil dash-pot cylinder is commercially incorporated with the main power cylinder in the Logan Air-Draulic drive. As with the independent oil cylinder, this device can be arranged for external cam control of the metering action. The Bellows Senacon Hydro-Check, a specialized cylinder designed primarily for drill press feeding, gives a dash-pot action in one direction and free return.

AIR-WATER DISPLACEMENT CYLINDERS: Hydraulic action may be found a necessity on some jobs, and yet there may not be the room or the time to provide a supplemental dash-pot cylinder. An effective substitute arrangement can be employed which utilizes two vertical-displacement cylinders. Air pressure acts on the surface of the liquid in the displacement cylinders. Speed is controlled by needle valves between the displacement cylinders and the power cylinder. The only serious disadvantage is that the fluid tends to entrain in the exhaust air.

It is not always recognized that plant water supply is an excellent source of hydraulic fluid at moderate pressure and is available even when compressed air is not. Smooth action may be obtained with pneumatic cylinders at low investment and operating costs. It is necessary, however, that the cylinder materials be corrosion-proof. Many manufacturers supply brass or chrome-plated cylinder liners and chrome-plated piston rods at little or no extra cost. The standard line of Tomkins-Johnson cylinders, for instance, uses all chrome-plated rubbing parts. Thought also should be given to water hammer and suitable arresters should be used if the required flow rate is large.

Factors Influencing Operation

A number of methods of air-cylinder speed control have been described—some simple and inexpensive, others elaborate as required for special applications. Choice will depend not only upon the motion requirements of the machine but also upon a multitude of factors, some of which may be impossible to anticipate during design. Speed of operation of an air cylinder is determined by the mass and resistance of the load, upon the air pressure at the machine, and upon the size and effective length of the supply and exhaust piping and valves. Usually, these factors can be approximated. Operating speed also depends upon the condition of the leathers and packings in the cylinder, upon alignment, and upon the state of lubrication of both the air cylinder and the load factors which can only be approximated in advance. If design is not to be unduly conservative, with necessary investment correspondingly high, occasional inadequacies of judgment must be considered inevitable.

It is hoped that some of the suggestions in this brief discussion may help the designer balance on his fence of cost compromise and also assist in developing inexpensive, rapid solutions when the design does prove inadequate.

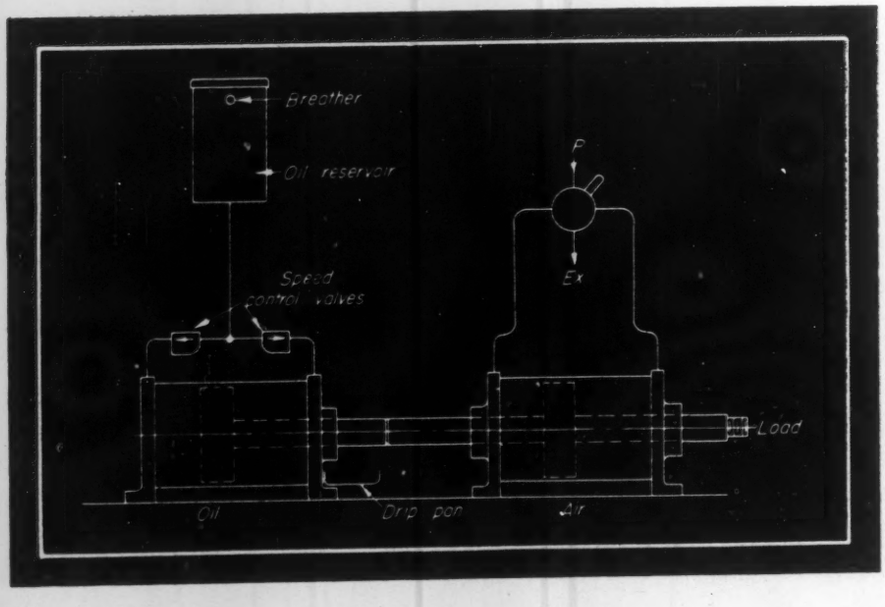
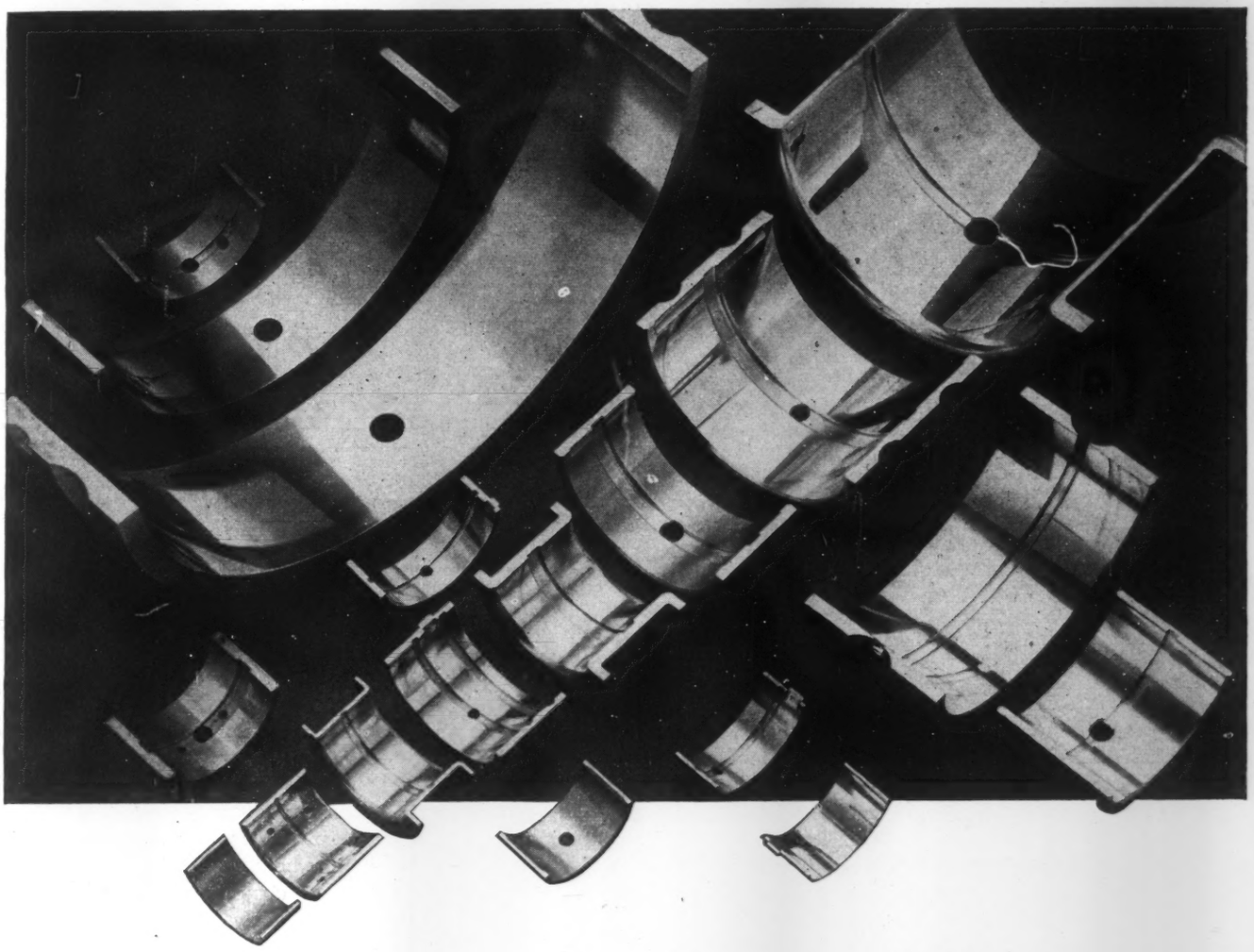


Fig. 4—Supplemental hydraulic cylinder utilized as dash-pot for speed control of pneumatic piston



Aluminum Alloy Bearings

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ALUMINUM ALLOYS with mechanical and physical characteristics specifically adapted to meet the requirements of modern high-duty bearing service are of comparatively recent origin. Property, application and design data on some of the most promising alloys are presented in this abstract of a paper presented at the recent annual meeting of the American Society for Metals in Atlantic City

CHIEF commercial production of solid aluminum bearings in the United States has been for diesel engine service where factors of speed and temperature coupled with well developed mechanical designs have been favorable, and ordinary types of babbitt or copper-lead lined bearings have been unsatisfactory because of the high bearing loads. The satisfactory performance and long life of such bearings in dynamometer tests and actual service led to their approval and production for main bearings, cam bearings and auxiliary drive bearings in aircraft engines.

At the present time, aluminum alloys predominating in the bearing field are those containing tin. The effects of

MECHANICAL AND PHYSICAL PROPERTIES OF ALUMINUM BEARING ALLOYS

Properties	750-T533 Permanent Mold Casting Heat Treated	750 Permanent Mold Casting Cold Worked[6]	XA750-T7 Permanent Mold Casting Heat Treated	XA750 Permanent Mold Casting Cold Worked[6]	XA80S-0 Sheet Annealed	XA80S-1/4H Sheet Cold Rolled	XB750-T533 Permanent Mold Casting Heat Treated
Tensile Strength psi	22000[7]	23000[9]	22000[7]	23000[9]	21000	25000	30000[7]
Yield Strength in Tension (psi)[1]	10000[7]	16000[9]	10000[7]	17500[9]	8000	23000	20000[7]
Yield Strength in Compression (psi)[1]	10000[8]	16900[9]	10000[8]	17000[9]	—	—	20000[8]
Elongation (per cent)[2]	12[7]	8[9]	10[7]	7[9]	25	6	5[7]
Brinell Hardness	45	50	45	50	—	—	70
Rockwell "H" Hardness	75	85	75	85	7	9	100
Shear Strength (psi)	14000		14500				21000
Endurance Limit psi[3]	9000	—	9500	—	—	—	—
Density	2.88	2.88	2.83	2.83	2.83	2.83	2.88
Thermal Conductivity[4]	0.44	0.44	0.40	0.40	0.40	0.40	0.43
Coefficient of Thermal Expansion[5]	0.0000135	0.0000135	0.0000132	0.0000132	0.0000132	0.0000132	0.0000133[10]

1 Offset = 0.2 per cent.
2 Gage length = 4D.
3 Based on 500,000,000 cycles, R. R. Moore Rotating Beam Test.
4 Cgs units, calculated from electrical conductivity.
5 Per degree F, temperature range 68 to 392 F.
6 Properties of hollow cylindrical bearing casting with 4 per cent axial reduction.
7 Tension values obtained from standard half-inch diameter tensile test specimens, individually cast in a permanent mold and tested without machining the surface.
8 Compression values obtained from half-inch diameter specimens with $1/r$ ratio of 6.
9 In the tangential direction.
10 Estimated.

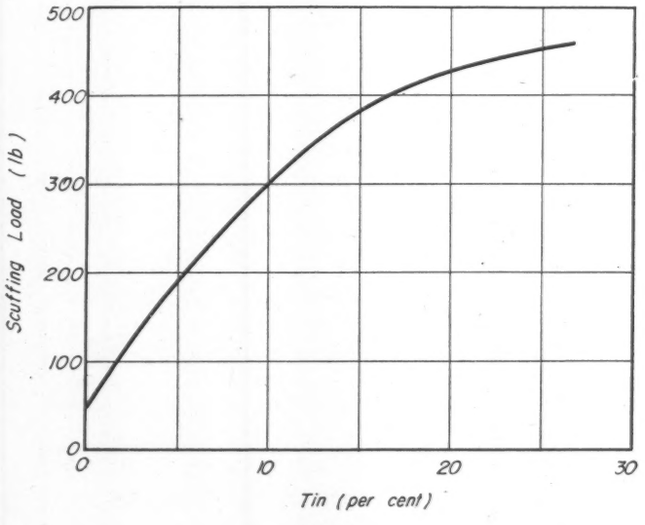
this element in aluminum on the bearing characteristics have considerable similarity to those of lead in copper-lead, leaded-bronze and gridded bearings. A progressive improvement in resistance to scuffing of the bearing and scoring of the journal and a reduction in the tendency for seizure are provided by increasing concentrations of this element. The general relation of bearing properties and tin concentration is probably of the shape shown in *Fig.* 1, which is based on the loads required to produce scuffing failures of a series of aluminum-tin alloys under conditions of thin-film lubrication. It is evident that it would be desirable to employ tin concentrations of perhaps 20 to 30 per cent to take advantage of the superior antifrictional characteristics; however, the mechanical requirements of most bearings, particularly those subjected to dynamic loading, place an upper limit on the useful tin content.

The influence of progressive tin additions on the mechanical properties of chill castings of aluminum containing about one per cent copper and one per cent nickel, and stabilized by heat treatment are illustrated in *Fig.* 2. The best combinations of strength and ductility occur within the range from about three to ten per cent tin; above about ten per cent these properties decline progressively.

Another group of alloying elements which have a significant influence on the bearing characteristics of the aluminum bearing alloys are those which introduce new phases of greater hardness than the aluminum matrix. Among the elements of this group with effects of practical interest are: Nickel, silicon, iron and manganese.

It has been indicated by numerous laboratory tests as well as practical experience that the presence of a substantial amount of a relatively hard constituent in the aluminum alloys increases their resistance to scuffing, allows higher unit loads to be applied without frictional failure, and enhances wear resistance. There are further indications that the load-carrying capacity increases with the hardness. Of the elements in this category, nickel has been used to the greatest extent in the commercial alloys. Nickel has favorable effects on the mechanical characteristics at elevated temperatures, creep resistance and coefficient of thermal expansion. Silicon, in the alloys containing in excess of about one per cent of this element, occurs primarily in the form of elemental silicon particles, although small amounts may be combined in the form of αAl-Fe-Si, βAl-Fe-Si or more complex phases. The silicon particles are normally extremely fine in rapidly solidified castings and distributed interdendritically. In the as-cast condition these particles are angular; however, spheroidization and coalescence may be accomplished by thermal treatment with an accompanying improvement in mechanical properties, machining characteristics and bearing qualities. Useful concentrations of these elements are

Fig. 1—Below—Improvement in seizure resistance of aluminum effected by addition of tin. Best combination of strength and ductility, however, occurs with tin content ranging from about three to ten per cent



limited by the reduction in ductility and increased hardness produced by progressive increments. Iron and manganese additions, among others, have effects similar to those of nickel and silicon, but are less desirable from the structural standpoint.

MECHANICAL STABILITY OF SOLID ALUMINUM BEARINGS: An important factor involved in the metallurgy of solid aluminum bearings arises from the difference in the thermal expansion coefficients of the bearings and the ferrous alloy connecting rods and crankcases in which they usually are installed for engine applications. Precision bearings normally are assembled with an interference fit which rapidly positions them in the bore of the housing and provides minimum resistance to the flow of frictional heat from the bearing to the supporting member. When the coefficient of thermal expansion of the bearing exceeds that of the housing, as in the case of an aluminum bearing in a steel connecting rod, the temperature rises accompanying operation will create thermal compressive stresses in the tangential direction in the bearing which are additive to the stresses developed by the initial interference of the assembly.

Stability of the mechanical fit in this type of installation is governed by a number of factors, the most important of which are: Operating temperature range, difference in thermal expansivity, initial interference or prestress, ratio of radial cross-sectional areas of the bearing and supporting member, and the mechanical properties of the bearing. Specific behavior also depends upon the type of operation —whether continuous at high temperature or normally interrupted by periods at low temperatures. From the standpoint of the bearing material the significant properties involved are the magnitude of the coefficient of thermal expansion, the stress-deformation curve and the resistance to creep or relaxation at operating temperatures.

Description of Commercial Alloys

ALLOY 750: Alcoa 750 alloy, introduced in 1939 (1)*, has been employed commercially in this country to a greater extent than any other aluminum alloy specifically intended for bearings. Nominal chemical composition of this alloy is 6.5 per cent tin, 1 per cent nickel, 1 per cent copper, the balance aluminum of commercial purity. This material was intended for and has been used principally in the form of permanent-mold castings which, by virtue of their rapid solidification, are typified by a fine, dense, strong and fatigue-resistant structure. A stabilizing thermal treatment designated T533 and consisting of heating for a period of several hours at a temperature slightly below the eutectic temperature normally is applied to castings of this alloy.

Typical mechanical and physical properties of alloy 750-T533 castings are listed in the accompanying table. Solid aluminum bearings machined from permanent-mold castings of this alloy have been used principally in the heavy-duty engine field where their satisfactory performance under conditions of very high unit loading at medium speeds and temperatures has verified early laboratory findings of good bearing characteristics, high load capacity, fatigue resistance and excellent resistance to corrosion.

Bearings of Alloy 750 function without difficulty under conditions leading to substantial shaft deflection which, if severe, may cause local permanent deformation or "bell mouthing" resulting in improved distribution of the bearing load without damage to the journal or impairment of engine performance. The aluminum alloy with its higher yield strength will not deform at as low loads as thick-lining babbitt bearings nor to the extent that such bearings deform under equivalent loads. The degree of embeddability, although undoubtedly lower than that of thick babbitt, has been indicated to be adequate for most installations. Hard foreign particles carried into the bearings through the oil supply have been shown to embed in Alloy 750, preventing accelerated abrasion of the journal.

On some occasions under extremely severe conditions of loading or deflection, or when unusual amounts of particularly harmful foreign material have been present, scuffing or galling of Alloy 750 bearings has been encountered. In most cases this occurrence has been traceable to improper design or installation. It usually is accompanied by adherence of a thin film of the aluminum alloy to the shaft. Removal of this thin aluminum coating from the steel journal by means of abrasives or dilute caustic solutions has in practically all cases revealed the absence of any detrimental effect on the journal surface.

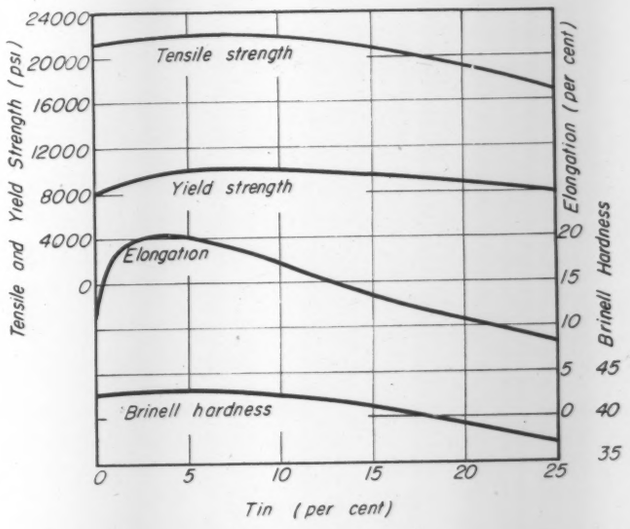


Fig. 2—Effect of tin concentration on various tensile properties and hardness of an aluminum matrix containing 1.1 per cent copper and 1.1 per cent nickel. Alloys were stabilized by thermal treatment

Cold working is used on Alloy 750-T533 to improve its strength and stability for service at higher operating temperatures. The effects of cold reduction on the mechanical properties of cylindrical 750-T533 bearing castings of medium diameter and wall thickness are shown in *Fig.* 3. A considerable improvement in elastic range and yield strength is accomplished by such treatment without a substantial increase in indentation hardness The mechanical properties resulting from a cold reduction of 4 per cent are listed in the table. No changes in bearing characteristics of practical magnitude attributable to the cold-working treatment have been detected.

ALLOY XA750: This alloy has a chemical composition

* Numbers in parentheses indicate references listed at end of article.

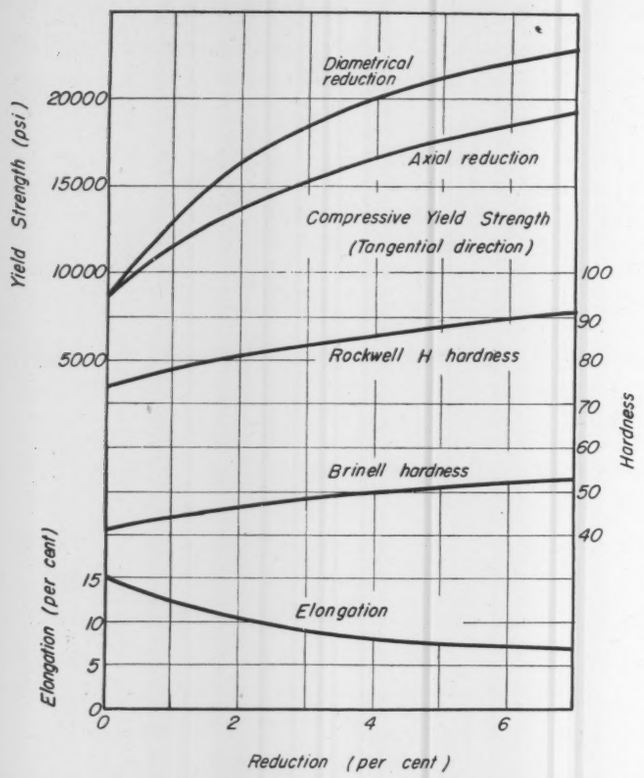


Fig. 3—Effect of cold reduction on the mechanical properties of cylindrical 750-T533 alloy castings

similar to that of Alloy 750, except for an addition of silicon. Although it has not been used on a large scale commercially, its high order of antiscuffing properties, low friction and high wear resistance under conditions of boundary and thin-film lubrication give considerable promise of further application.

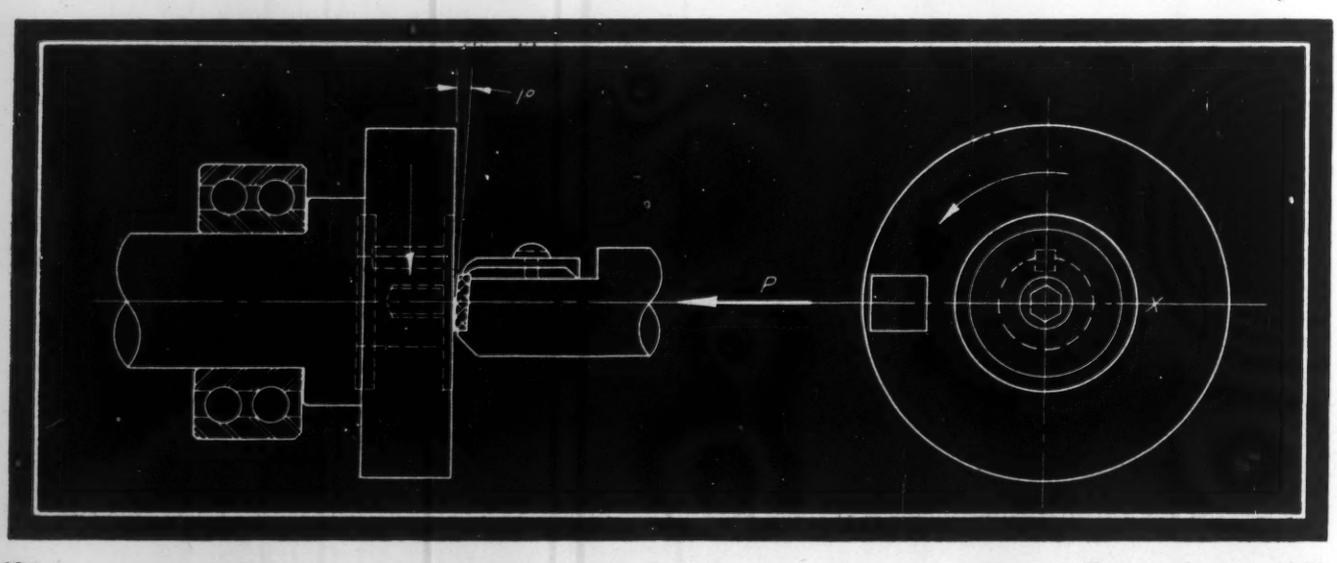
This material is also produced in the form of permanent-mold castings which are normally given a solution heat treatment at a relatively high temperature followed by quenching in a medium which results in a minimum of internal stress, and a stabilizing thermal treatment of several hours at a temperature somewhat below the melting temperature of the tin-aluminum eutectic. This entire thermal treatment is identified by the suffix T7. The silicon particles are spheroidized by the solution heat treatment with a resultant improvement in ductility and machinability. In addition, silicon particles of spheroidal shape are believed to be more desirable from the standpoint of bearing characteristics than the angular shapes present in the as-cast structure. The stabilizing treatment results in low residual stress, reduced potential growth and a moderate increase in strength.

Mechanical and physical properties normally obtained in this material are listed in the table. The unusual bearing characteristics of this material have been demonstrated primarily by laboratory tests, although confirmatory evidence of its superiority has been obtained in some bearing installations. Its performance in a highly accelerated laboratory scuffing test, illustrated schematically in *Fig.* 4, has been outstanding. A detailed description of the testing equipment and procedure has been reported previously (2). The results of comparative tests of this aluminum-base alloy, a babbitt, copper-lead, and a high-lead bronze are illustrated in *Fig.* 5, which is a photograph of the samples at the conclusion of the test. Other tests have indicated that this alloy as well as the other aluminum-base bearing materials are somewhat more sensitive to complete failure of the lubricant supply than tin or lead-base alloys but compare favorably in this respect with other bearing materials used for high-duty service.

The stress-deformation characteristics of Alloy XA750-T7 are practically identical with those of Alloy 750-T533, and the properties of the two materials after cold working are similar. Conformability and embeddability of the two alloys do not appear to differ to any great extent, and the resistance to fatigue of Alloy XA750 cast bearings has been indicated to be equal to that of Alloy 750 bearings. Although the coefficient of expansion of this material is somewhat lower than that of Alloy 750, the difference is not great enough to effect a difference of practical magnitude in the thermal interference stresses developed in ferrous alloy connecting rods or crankcases, and the maximum operating temperatures are subject to limitations similar to those which apply to Alloy 750 bearings.

ALLOY XA8OS: The aluminum-tin alloys, in common

Fig. 4—Schematic diagram of setup used in testing the scuffing resistance of bearing materials



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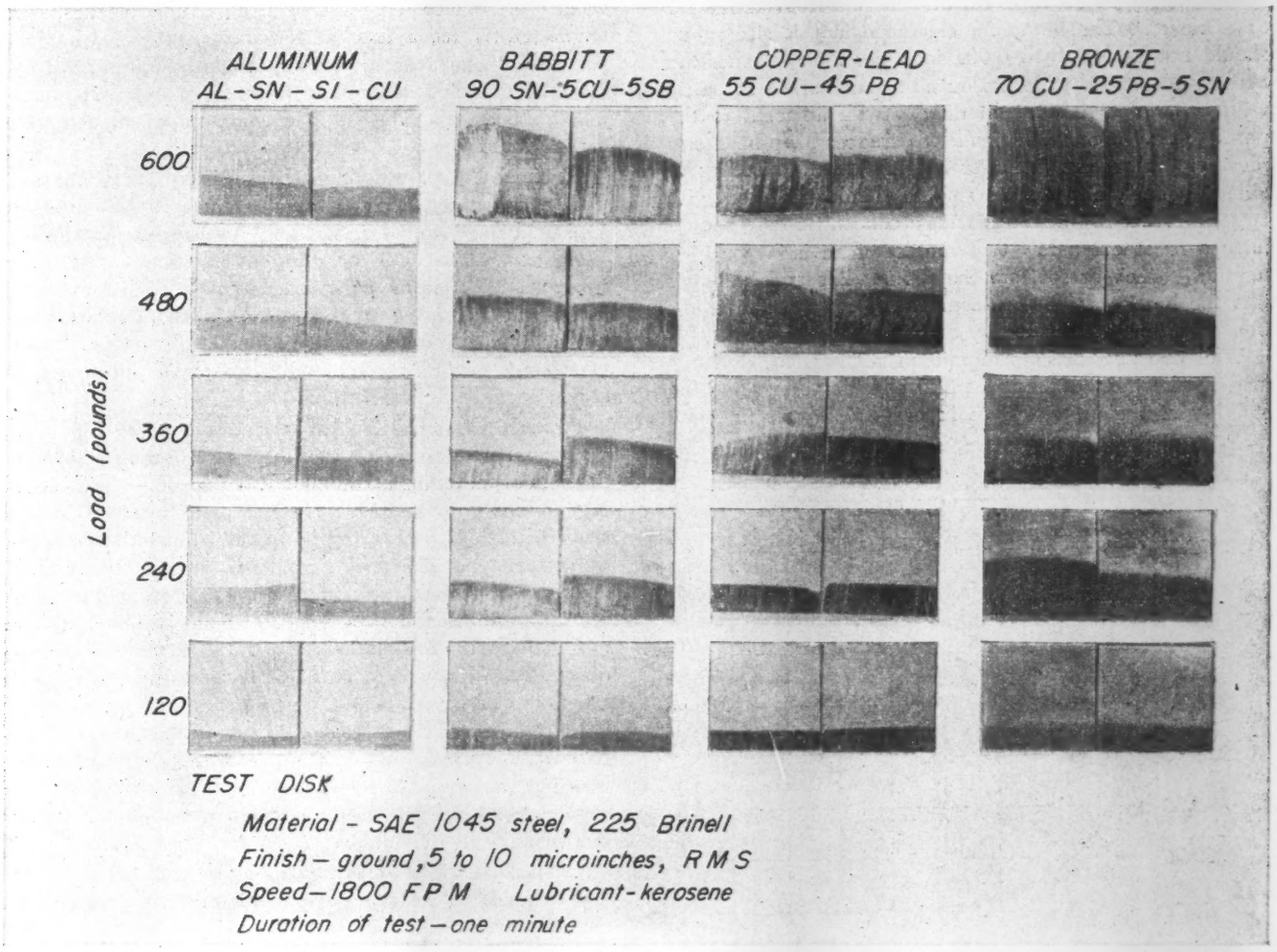

Fig. 5—Photograph of some samples after scuffing test affords graphical comparison of scuffing resistance of aluminum bearing material and three other bearing alloys

with most other types of bearing materials, are notably hot-short, and early attempts to produce wrought forms of these alloys were discouraging. Considerable experimental work, however, led to a process by means of which the silicon-containing alloy can be produced commercially as sheet or strip. The wrought form of this alloy has been designated XA8OS.

Control of the mechanical properties can be attained readily by limiting the final cold reduction. Changes in the mechanical properties produced by various degrees of cold reduction by rolling are illustrated in *Fig.* 6. A limiting value of the yield strength may be established by the conformability and embeddability requirements of individual applications. Properties of XA8OS-O (annealed) and XA8OS—¼H (cold rolled) sheet are listed in separate columns of the table. Fatigue resistance and load-carrying capacity of bearings formed from XA8OS alloy are indicated by available data to be equivalent to those of bearings produced from high quality permanent-mold castings of XA750 alloy.

ALLOY XB750: An alloy containing higher concentrations of copper and nickel than the alloys previously discussed, and an addition of magnesium, recently has been developed for applications requiring operation at higher temperatures and improved resistance to thermal stresses. This material is expected to extend the range of applicability of aluminum bearings into fields for which the lower strength alloys are not entirely satisfactory. It is intended primarily for production of castings by the permanent-mold process.

An aging treatment, designated T533, consisting of heating for several hours at a temperature below the solidus, is employed to develop the desired mechanical properties, which are listed in the table. This material is characterized by higher hardness and yield strength and a lower elongation than the alloys described previously. Consequently, plastic deformation to accommodate deflections or foreign particles in the oil clearance cannot take place as easily in bearings of this material as in the softer alloys. Resistance to thermal strain and creep are considerably better, permitting, under conditions of restricted expansion, operation at higher temperatures than are ordinarily practical with the lower strength materials. Fatigue resistance not inferior to that of the lower strength alloys is indicated by available test results.

Design Of Solid Aluminum Bearings

Principles of good mechanical design of sleeve bearings, particularly those factors which influence the formation and retention of a lubricant film, should be adhered to in the design of aluminum alloy bearings. An oil clearance of 0.001 to 0.0015-inch per inch of journal diameter

is satisfactory in bearings ranging in size from about 1.5 to 8 inches. The minimum clearance in this size range should not be less than 0.001 inch per inch whether the bore is concentric with the outside diameter or eccentric with a 0.001 to 0.002-inch thinner wall adjacent to the parting line. Somewhat smaller clearances have been employed with success in larger bearings, while bearings of about 1.5-inch diameter or smaller should be fitted with larger clearances. Bearings with a concentric bore should have a relief cut a few thousandths of an inch deep extending ¼-inch or so from the parting line and blending into the bearing surface to compensate for a slight distortion which may be caused by the crush.

Wall thickness of solid aluminum bearings for dynamic load applications deserves careful consideration since the stability of their interference fit or their fatigue life may

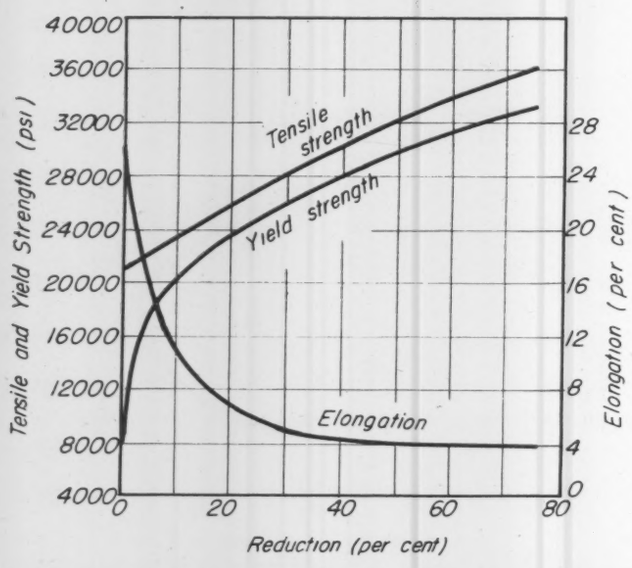

Fig. 6—Curves show the mechanical properties of XA80S bearing alloy sheet after various cold reductions

be governed by this dimension. For best results, it is recommended that the wall thickness should not be less than the value obtained by using the relation

$$T = 0.04D + 0.02, \text{ or } T = 0.044a + 0.02$$

where T = minimum wall thickness of bearing, inches, D = bearing outside diameter, inches, and d = journal diameter, inches.

When a dowel is used for endwise location and for locking the bearing against rotation, a wall thickness of 5/32-inch is considered to be the minimum (3), although this thickness allows for a circumferential oil groove in registry with the dowel hole which reduces the effective surface area at the dowel. When locking tangs of conventional type are used, the wall thickness should not be less than about 0.100-inch for bearings subjected to high dynamic loads. The applicability of thinner bearings depends upon the severity of operating conditions.

Precision machining and fine finishing of the bearing outside diameter and parting faces as well as the housing bore surface are essential for satisfactory fitting and optimum performance. A finish of 10 to 15 microinches, rms, or better, is recommended for these surfaces wherever practical. The bearing surface roughness should not exceed 25 microinches, rms, in most cases and it is preferable to finish the journal to a comparable value for the rapid attainment of a "run-in" condition.

Applicability of aluminum bearings to truck, bus and passenger car engines is dependent to a considerable extent upon mechanical design and crankcase temperatures. Field experience with the different alloys, manufacturing processes and treatments which may be used has not been sufficiently extensive to define closely the limitations in operating conditions applicable to these bearings. However, some general recommendations may be presented to serve as guides in their utilization.

Properly designed and manufactured Alloy 750 bearings should provide a service life of several thousand hours in engine operation at unit loads up to 4000 psi. Bearing pressures up to 6000 psi have been sustained for extended periods. A bearing life several times that attained by certain types of babbitt, copper-lead or cadmium-alloy-lined bearings has resulted in engines which operate at maximum unit loads in the range of 2000 to 3000 psi. The most successful installations are those in which bearings of generous dimensions, particularly in wall thickness, can be used. Although the fatigue resistance of steel-backed babbitt bearings increases markedly with reduction in the babbitt lining thickness, in the case of solid cast aluminum bearings the optimum fatigue life increases and the effects of structural defects or unsoundness are minimized with increasing wall thickness.

Crankshaft speeds resulting in peripheral velocities below about 2000 surface feet per minute have prevailed in engines where the aluminum bearings have been most successful. High speed, per se, does not appear to be a critical factor, but its usual accompaniment, high temperature, introduces practical limitations.

The permissible maximum operating temperature for solid aluminum bearings, when the expansion is controlled by iron or steel supporting members, usually is governed by the allowable change in the interference fit rather than by the reduction in oil film thickness which accompanies increased temperatures, and will depend upon the alloy, its treatment and processing. In the case of 750-T533 or XA750-T7 bearings, partial loss of crush may occur during operation at temperatures of 200 to 225 F, and sufficient creep may take place at higher temperatures that the bearings will not maintain a positive interference at low temperatures. This may or may not affect the performance of split bearings, but might lead to difficulty during cold starting. Operating temperature for these bearings probably should not exceed 225 F. With the increased strength provided by cold working, the operating temperature may be increased to about 250 F. Split bearings of the higher-strength alloy, XB750-T533, are indicated to be satisfactory for operation at temperatures up to 300 F. Bushings or full-round bearings, however, probably should not be operated at temperatures in excess of 225 F if cold operation is also required.

Both steel and cast-iron crankshafts have been used successfully with aluminum bearings. Although the hardness of the journal surface does not appear to influence significantly the load-carrying capacity of the bearings, lower wear rates may be experienced with hardened journals.

The journal wear encountered in engines employing Alloy 750 bearings has been reported not to exceed that formerly obtained with babbitt bearings (4); however, laboratory tests at high unit loads have indicated a journal wear rate somewhat higher than that encountered with babbitt but not greater than the rate resulting from operation of copper-lead bearings.

Experience in the commercial application of Alloy XA750-T7 bearings has been somewhat limited. This material may be used for split bearings or bushings in ferrous alloy supporting members if the thermal stress limitations applicable to Alloy 750-T533 are not exceeded. It is suitable for applications involving boundary lubrication and high speeds as well as high temperatures where the mechanical conditions do not introduce high thermal stresses. Such applications include thrust and segment bearings. Promising results have also been obtained with Alloy XA750-T7 floating bushings.

The high resistance of the aluminum-tin alloys to corrosive attack by the organic acids formed in the oxidation of lubricating oils during use is a definite advantage, and leads to the possibility of using compounded oils in engines where previously corrosion of bearings made it impractical to take advantage of the superior properties of such oils. Compounding to increase the lubricating qualities of the oils or to prevent accumulation of sludge deposits, ring sticking, etc., is made possible by the improved chemical stability of aluminum bearings. Laboratory tests have also indicated that aluminum has no catalytic effect on the oxidation of lubricating oils whereas certain other metals used in bearings are recognized to accelerate the rate of oxidation.

Conservation of tin may be effected by employing aluminum-tin alloy parts in place of some types of steel-backed tin-babbitt bearings with ordinary lining thicknesses, bronze-backed babbitt-lined bearings or solid bronze bushings. This reduction in total tin content arises chiefly from the lower density of the aluminum bearing alloys. The reduced weight of connecting rod assemblies equipped with aluminum bearings may also lower the inertia loads, and although this advantage is ordinarily of minor importance in slow-speed applications, it may become a significant factor where high rotativte speeds are involved.

Although most of the commercial experience with aluminum bearings has been in internal combustion engines, the operating requirements for such bearings are undoubtedly much more severe than those prevailing in the bearings used in many other types of mechanical equipment. As testing and experience accumulate and the economic factors are adequately appraised, it is expected that the field of application for aluminum alloy bearings will be greatly extended.

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Remote Reading Tachometer Utilizes Capacitor Circuit

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DESIGNED to replace a flyball tachometer for indicating vibrational frequency of a mechanical test table, a simple make-and-break type of capacitor tachometer has solved many of the annoying problems previously experienced. This tachometer also has proved useful in a variety of other counting and measuring applications, especially where a small motion is to be counted.

The mechanical tachometer was not accurate at low frequencies of vibration and could not be adjusted to give correct readings. In addition, the drive cable between the tachometer pickup and the instrument required careful maintainance and constant lubrication. Contrasted to this, the capacitor tachometer, the pickup for which is shown in *Fig.* 1, requires only two leads to be connected to any remote indicator station. It is easily checked and adjusted, and has valuable performance characteristics. The indicating scale is linear, making accuracy of reading at all speeds possible, yet the circuit illustrated is satisfactory for shaft speeds from 300 to 6000 rpm. Operating on 115 volt, 60 cycle power, the instrument draws only ten watts.

The tachometer incorporates a rotating cam powered by

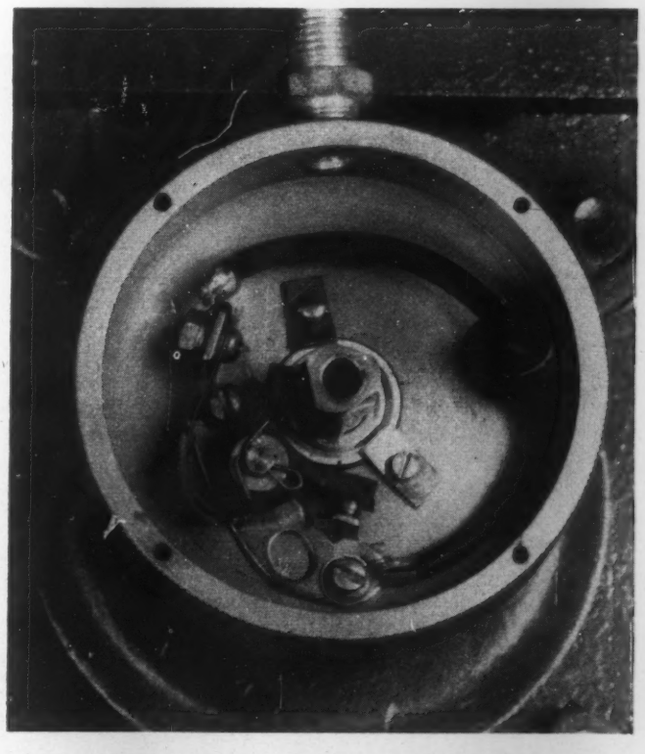


Fig. 1—Detail of tachometer pick-up unit. Three-lobe cam on shaft actuates spring-loaded bell crank, opening circuit

the unit being inspected. This cam actuates a set of electrical contacts, opening and closing of which charges and discharges a condenser. Discharge current is rectified and applied to a damped zero-to-one milliampere meter calibrated in revolutions per second. A simplified schematic of the tachometer circuit showing the important components is shown in *Fig.* 2. Resistor is a current limiting device, large enough to limit the current to a satisfactory value when the contact is closed by the rotating cam yet small enough to permit complete charge of the condenser when the contact is open.

If the condenser is completely charged and discharged with each break and make of the contacts, then the quantity of electricity in coulombs equals

$$Q_1 = CE$$

where C is the capacity of the condenser, in farads, and E is the potential applied across the condenser, in volts. For N makes or breaks of the contacts, the total charge is

$$Q = NCE$$

Dividing by the time in seconds, t, required by this operation,

$$\frac{Q}{t} = \frac{NCE}{t}$$

By definition, Q/t is the current, I, in amperes and, since both C and E are constant for any particular piece of apparatus,

$$I = A\frac{N}{t}$$

where A is constant of multiplication for the instrument in question. This equation shows that the current through the meter is directly proportional to the number of contacts per second and is a measure of the rotational speed of the shaft.

As illustrated in *Fig.* 3, the complete circuit includes a transformer stepping down line current to 6.3 volts. When rectified and filtered by a conventional circuit, a direct-current power supply of about eight volts is provided.

Performance of the unit has been found satisfactory. With an interrupting cam with three lobes, speeds as low as 5 rps have been recorded. Flickering of the meter needle has been experienced only when using a single-lobe cam at 5 rps. Using a line-voltage regulating transformer and a calibrating resistor, measured error at full-scale reading has not exceeded 3 per cent.

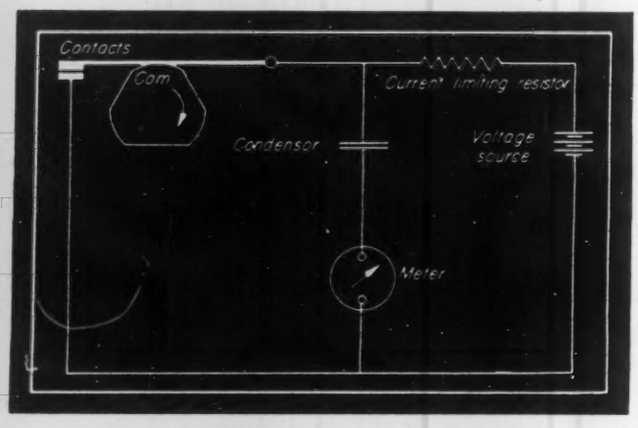
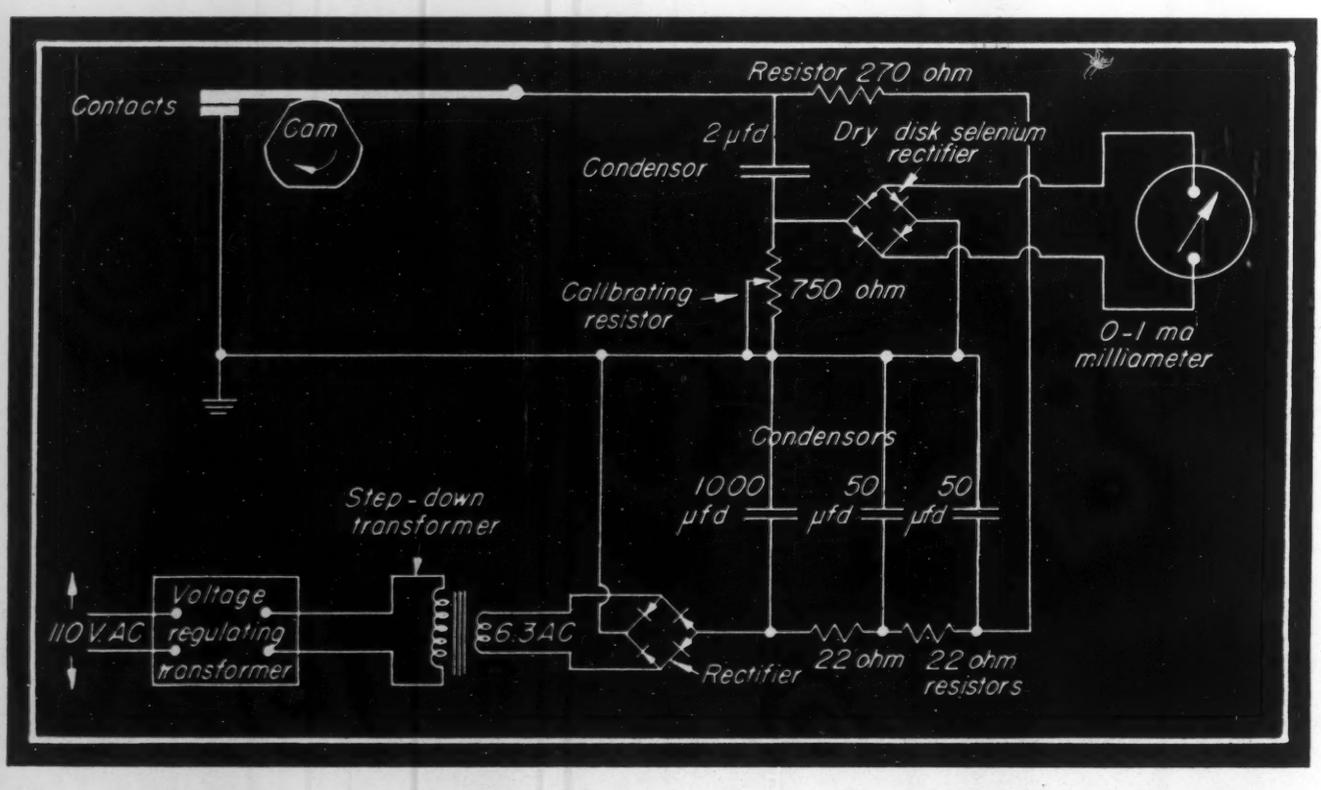
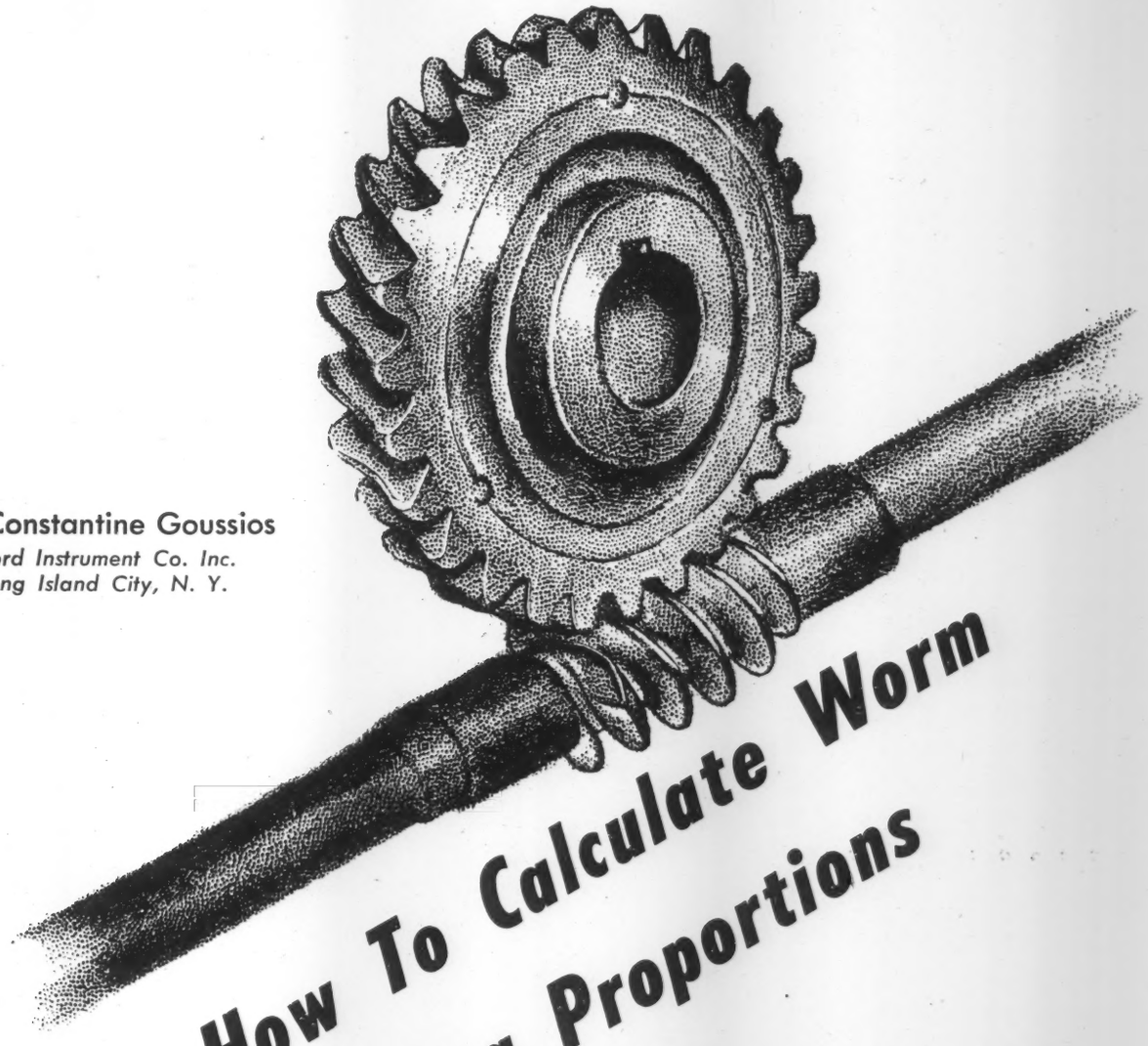


Fig. 2—Above—Simplified schematic of tachometer circuit. From a practical standpoint, a rectifier is needed in circuit

Fig. 3—Below—Complete circuit diagram of tachometer. Pick up is connected to control apparatus by only two leads and ground





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How To Calculate Worm Gearing Proportions

. . . when only speed ratio and center distance are given. Simple, direct-substitution method permits working to any degree of precision required

ALTHOUGH possessing many favorable characteristics, worm-gear drives present some difficulties when it comes to computing the proportions. In most initial designs the only values known are the speed ratio and the center distance. From this information the calculation of actual dimensions of the worm and gear usually is a somewhat tedious trial and error procedure.

Designers have for long sought a simple method of solving worm and worm gear problems by direct substitution, given speed ratio and center distance. The remaining independent variable is the pitch; inasmuch as most worm gears are hobbed on standard machines with standard cutters, the normal diametral pitch used in the computations must be a standard value. This article presents the analysis and an outline of a direct-substitution method that is simple, quick and accurate and leads to a solution having any desired degree of precision through a successive-approximation procedure.

To understand the method a graphical representation of the physical relationship between the worm and worm gear is required. This relationship is illustrated in *Fig.* 1, in which the hypotenuse of the triangle is parallel to the thread of the worm and the teeth of the gear. The symbols are defined in the accompanying Nomenclature. If the developed circumference of the pitch circle of the gear, πD_G, be added to πD_W and the angle whose tangent is N_W/N_G be drawn from the extremity, the result is *Fig.* 2, which is the basis of the method.

For an actual problem where center distance C and the speed ratio N_G/N_W only are known, there is an infinite number of solutions, a few of which are shown in *Fig.* 3. It will be evident, however, that only one point

on the curve will yield a desired length $\pi N_W/P_{nd}$, hence only one solution exists for each possible value of this function. Inasmuch as N_W must be an integral number and P_{nd} usually is a standard value, the actual choice of practical values is relatively limited.

In the discussion immediately following it is assumed that the diametral pitch, the number of threads on the worm and the number of teeth in the gear are given. However, it will be shown later that these values can be determined knowing only the distance between centers and the speed ratio of the driving and driven shafts.

Nomenclature

D_G	=	Pitch diameter of gear
D_W	=	Pitch diameter of worm
C	=	Center distance
N_G	=	Number of teeth in gear
N_W	=	Threads on worm
N_G/N_W	=	Ratio
p_n	=	Circular pitch (normal to helix)
l_W	=	Lead of worm
l_G	=	Lead of gear
λ	=	Lead angle
P_{nd}	=	Normal diametral pitch

Having established tentative values for N_W, N_G and P_{nd}, the procedure is to locate first an approximate solution, indicated by point C on *Fig.* 4. The exact theoretical solution is indicated by point T, and is approached by successive approximation, as explained in the following.

Since $D_G = N_G/P_{nd} \cos \lambda$ and λ is relatively small, the term πD_G is approximately equal to $\pi N_G/P_{nd}$, which is taken as the initial value of AC on *Fig.* 4. The length CD then is $(\pi N_G/P_{nd})\ (N_W/N_G) = \pi N_W/P_{nd}$, and the length CB is equal to $\pi 2C - (\pi N_G/P_{nd})$. The angle K then is given by the relation

$$\tan K = \frac{\pi N_W/P_{nd}}{\pi 2C - \pi N_G/P_{nd}} = \frac{N_W}{2C\,P_{nd} - N_G} \quad \ldots\ldots\ldots\ldots (1)$$

But the lead angle, λ, is given by the relation

$$\tan \lambda = \frac{N_W}{2C\,P_{nd}\cos\lambda - N_G}$$

hence by rewriting Equation 1 in the form

$$\tan K_1 = \frac{N_W}{2C\,P_{nd}\cos K - N_G} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

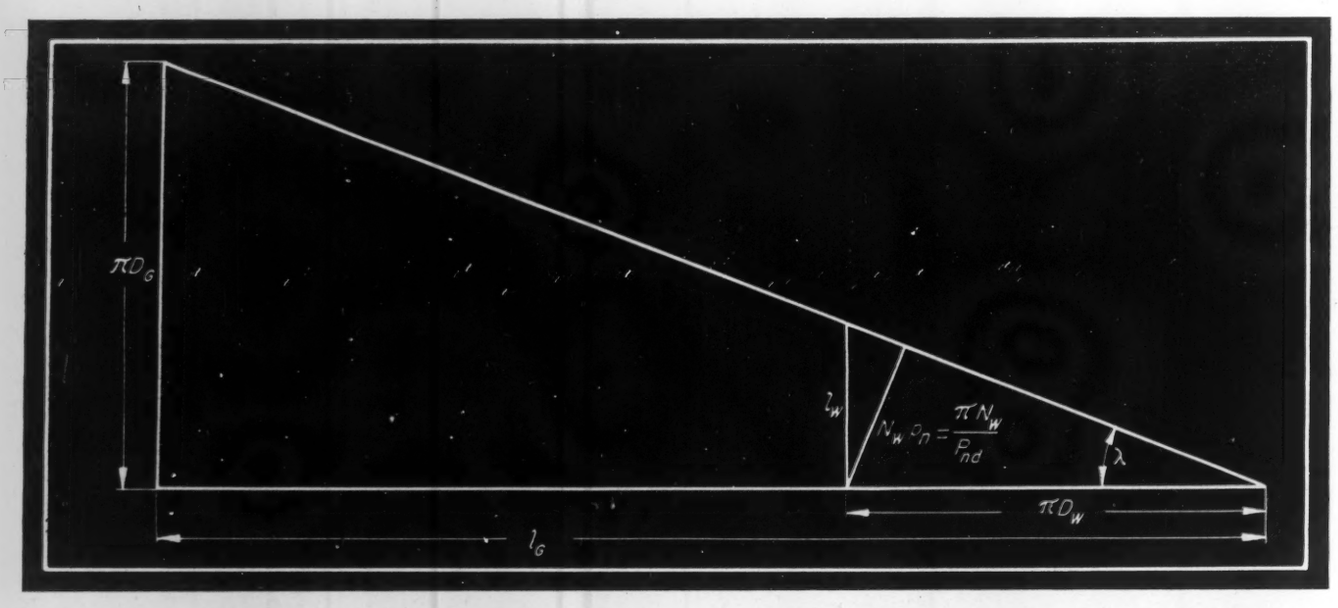
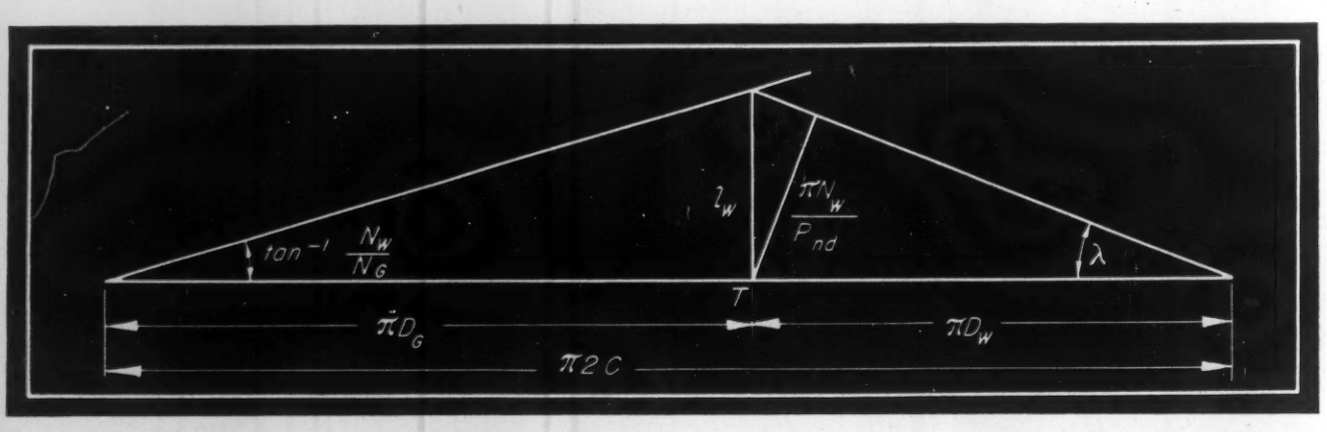


Fig. 1—Above—Developed surfaces of worm and worm gear pitch cylinders. Hypotenuse is parallel to thread

Fig. 2—Below—Graphical representation of problem to be solved when center distance and speed ratio are given



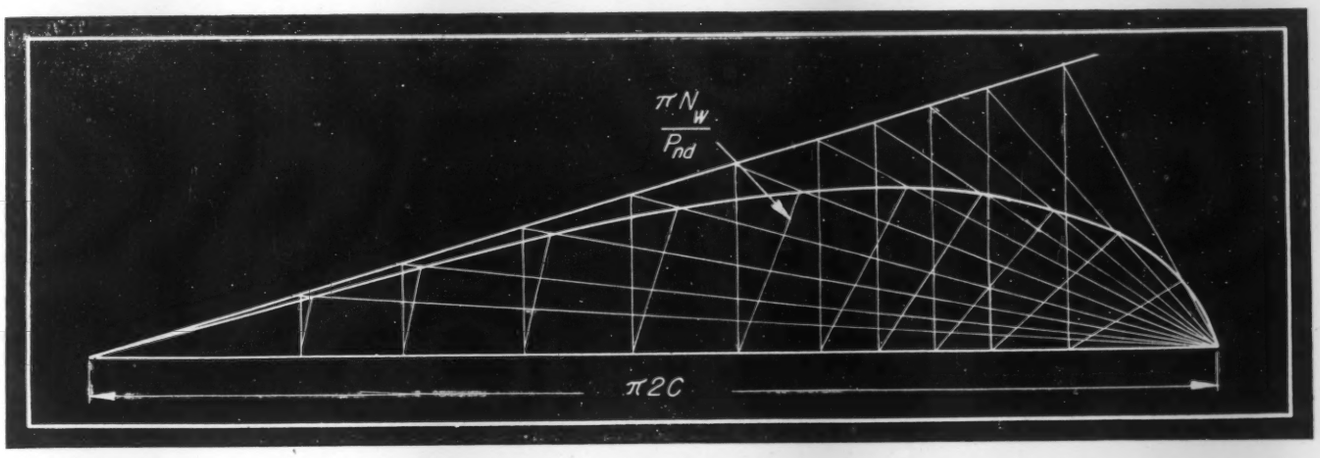
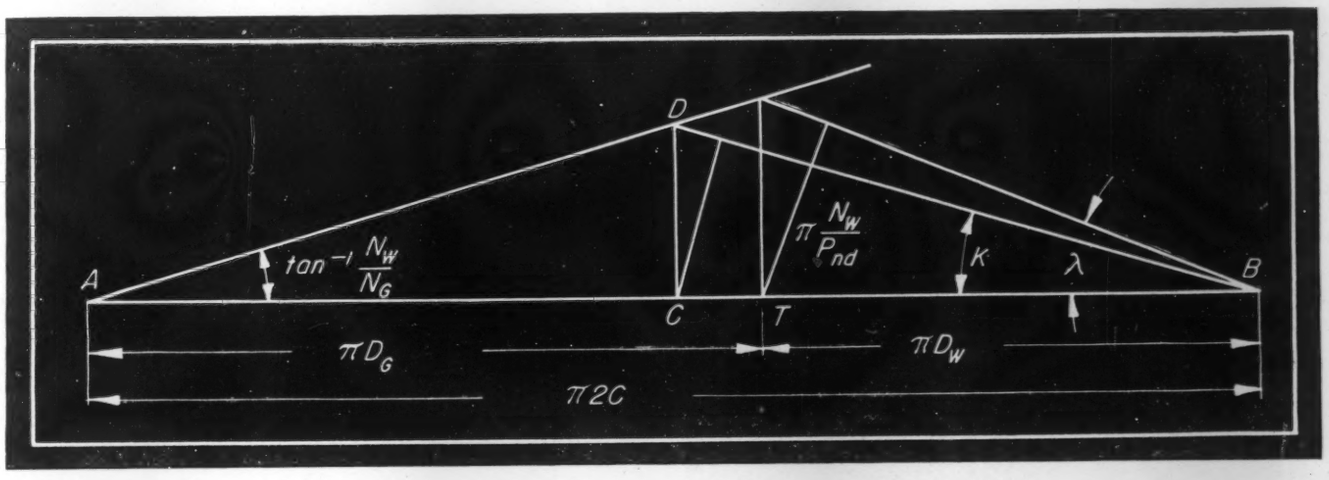


Fig. 3—Above—Result of assuming several values of diametral pitch and number of threads

Fig. 4—Below—Representation of solution by successive approximation from initial assumption, C, to the final theoretical solution, T



a closer approximation will result, giving a point C' closer to the theoretical point T on *Fig.* 4.

Continuing this procedure, a still closer approximation would be given by

$$\tan K_2 = \frac{N_W}{2C\,P_{nd}\cos K_1 - N_G}$$

By repeating this process a sufficient number of times the point C may be made to approach T to any desired degree of precision. The value of $\cos K$ may be found either from tables or by calculation, using the well known relation

$$\cos K = \frac{1}{\sqrt{1+\tan^2 K}} \qquad (3)$$

The process is repeated until the cosine does not change in, say, eight decimal places for two successive steps, depending upon the desired degree of precision.

Pictorial representation of the process is shown in *Fig.* 5. Each condition represents a mesh of a worm and a worm gear, but each one has a different diametral pitch; each step varies the diametral pitch, approaching the desired value for the final condition, which is the theoretical solution.

To select practical values of the diametral pitch and numbers of threads and teeth, it will be observed that these values must satisfy Equation 1. They must also satisfy the practical requirement that both pitch diameters be positive, that is, the denominator of Equation 1 must be positive. The procedure is therefore as follows:

1. Determine suitable values of N_W and N_G to give the correct speed ratio, which equals N_G/N_W
2. Select a suitable standard diametral pitch, P_{nd}, to satisfy the following conditions:

a. Denominator of Equation 1 should be positive

b. Angle K, which approximates the lead angle, should be as large as possible to give a satisfactorily small pitch diameter for the worm.

EXAMPLE: In the following a typical worm-drive problem is worked out in detail. The required speed ratio is 36 to 1 and the center distance 1.820 inches.

As a first attempt, a single-thread worm is assumed, that is, $N_W = 1$ and $N_G = 36$. Also P_{nd} is assumed equal to 32. Then, substituting in Equation 1,

$$\tan K = \frac{1}{3.640 \times 32 - 36} = \frac{1}{80.480} = 0.0124$$

This gives angle K only 0°43′ which is too small. Also

D_W, which is approximately equal to N_G/P_{nd}, is too large in relation to D_G. Trying a double-threaded worm and $P_{nd} = 16$,

$$\tan K = \frac{2}{3.640 \times 16 - 72} = \frac{2}{-13.760}$$

which involves a negative denominator. Trying $P_{nd} = 20$

$$\tan K = \frac{2}{3.640 \times 20 - 72} = \frac{2}{0.80} = 2.5$$

which gives an angle $K = 68°12'$, much too large, and a worm diameter much too small. Trying $P_{nd} = 24$

$$\tan K = \frac{2}{3.640 \times 24 - 72} = \frac{2}{15.360} = 0.13020833$$

which is satisfactory. Subsequent calculations will therefore use $N_W = 2$, $N_G = 72$ and $P_{nd} = 24$. From trig-

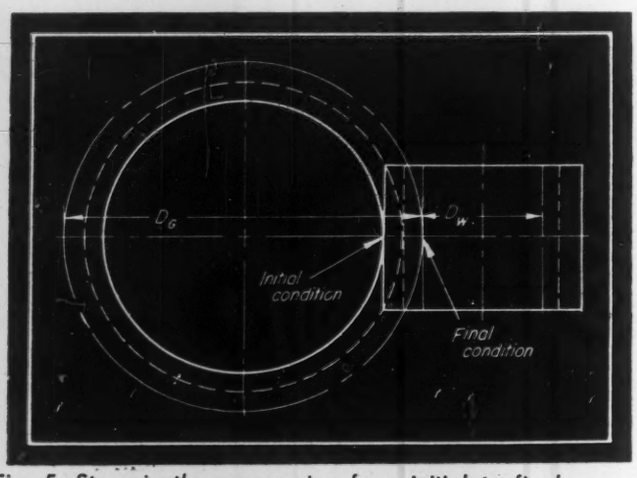


Fig. 5—Steps in the progression from initial to final conditions for worm and worm gear

onometric tables or by calculation, using Equation 6, *cosK* = 0.99162916. The subsequent computations are simple routine, involving successive substitution in Equation 2, and are summarized in the following:

$$\tan K_1 = \frac{2}{3.640 \times 24 \times 0.99162916 - 72} = 0.13671733$$

$$\cos K_1 = 0.99078324$$

$$\tan K_2 = \frac{2}{3.640 \times 24 \times 0.99078324 - 72} = 0.13741149$$

$$\cos K_2 = 0.99069068$$

$$\tan K_3 = \frac{2}{3.640 \times 24 \times 0.99069068 - 72} = 0.13748787$$

$$\cos K_3 = 0.99068047$$

$$\tan K_4 = \frac{2}{3.640 \times 24 \times 0.99068047 - 72} = 0.13749630$$

$$\cos K_4 = 0.99067929$$

$$\tan K_5 = \frac{2}{3.640 \times 24 \times 0.99067929 - 72} = 0.13749727$$

$$\cos K_5 = 0.99067919$$

$$\tan K_6 = \frac{2}{3.640 \times 24 \times 0.99067919 - 72} = 0.13749735$$

$$\cos K_6 = 0.99067919$$

Inasmuch as $\cos K_6 = \cos K_5$ to the eighth decimal place, the solution may be regarded as satisfactory, and the desired proportions are then $\cos \lambda = 0.99067919$, $\sin \lambda = 0.13621578$, $D_G = N_G/(P_{nd} \cos \lambda) = 3.02822551$, $D_W = N_W/(P_{nd} \sin \lambda) = 0.61177444$. Center distance is $C = \frac{1}{2}(D_G + D_W) = 1.81999998$, virtually the same as the required 1.820.

The number of times this process must be repeated depends on the size of the lead angle—the larger the angle the greater the number of steps. For small angles as few as three steps may be sufficient.

Values computed with the final cosine value may result at times in pitch radii whose sum is slightly greater than the required center distance. This is due to the nature of the given conditions and to the limitations of the calculating machine. In such a case the value of the cosine which will give a working center distance slightly less than that required may be obtained from a table of cosines of one second differences by taking the closest value which is less than the computed value. Computations made with this cosine will result in pitch radii whose sum is less by negligible amounts in the 7th or 8th decimal place.

The foregoing sample calculation does not, of course, represent the only solution for the given conditions, and it may be desirable to repeat the calculations for some other assumed values of N_W and P_{nd}. The results may then be compared and the most favorable all-round solution selected for the actual design.

Surface Durability of Gears

CORRECTION: In the July, 1946, issue of MACHINE DESIGN there appeared an article entitled "Evaluating Surface Durability of Gears" which was based on an A.G.M.A. paper by T. H. Wickenden, G. R. Brophy and A. J. Miller. It has been found that the general equation given for calculating the compressive stresses in gear teeth (Page 145) is in error and should have been

$$s_c = \frac{23{,}600 \cos\alpha}{PR \times \alpha \times \beta} \sqrt[3]{\frac{4T(\tan^2\alpha_n + \cos^2\Delta)^2}{\cos\Delta \sin^2\alpha_n}}$$

where PR is the pitch radius. The simplified equation $s_c = 15{,}600\sqrt[3]{T}$ for calculating the stresses under the conditions of the tests is correct.

MACHINE Editorial DESIGN

Leadership Needs Engineering Approach

Once again our country has been brought to the verge of chaos through the high-handed action of a power-hungry man claiming to represent three-tenths of one per cent of the population. In public discussions which raged during the coal strike misstatements of fact and distorted analyses of true facts went by unchallenged. Need for the sort of solid thinking that is the foundation of the engineer's training, to offset the fuzzy, emotional outlook that so easily sways the uninformed, was never more acute than today. Consequently, recent attempts to interest more engineers in participation in public affairs deserve wholehearted support.

In the keynote address at the recent annual meeting of the A.S.M.E., Congressman Carl Hinshaw of California, himself an engineer and one of the two engineers in the new House, pleaded for "more engineers in city councils, in state legislatures, in the Congress of the United States, and in positions of executive authority everywhere . . . The mechanical age which engineers have created demands engineering leadership in public life".

Another engineer in Congress, Senator Ralph Flanders of Vermont, one of the two engineers in the new Senate, also stressed the engineer's share of responsibility and pointed out that "we have lacked moral stamina to a greater degree than technical efficiency; but we must not forget that improvement of our material conditions . . . is dependent on the close cooperation of high morals with skillful business, financial, technical, and political techniques".

What the attitude of the engineer should be on public affairs was suggested by D. Robert Yarnall, A.S.M.E. president, who believes that "somewhere along the line, with the help of good environment and sound training, there must be built in us a sense of concern, a social conscience that will not be satisfied with personal success within the bounds of our profession, essential as that is, but that will drive us on and out with other citizens to carry our share of the burdens of the world's problems; assume our constructive part in responsibility for good, wholesome government; take seriously our part as engineers in helping resolve differences in social industrial conflict areas; and help in making secure these precious freedoms, among them the right without fear to write our letter to the editor and to the Congressman".

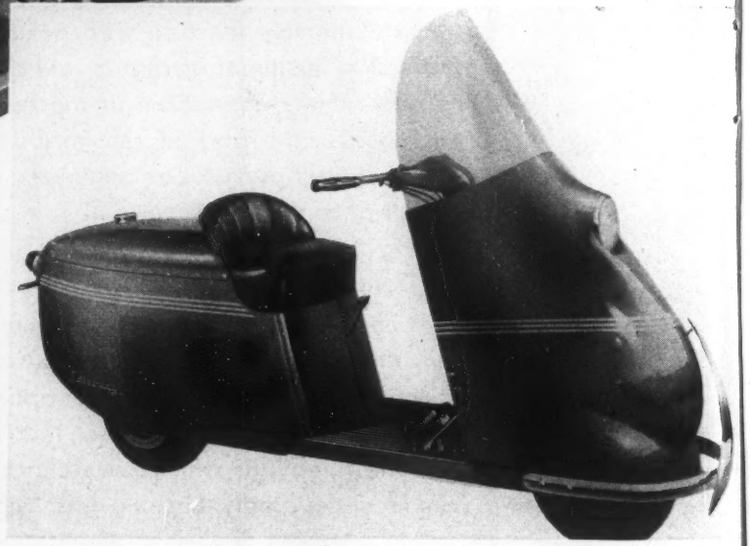
These suggestions represent certain basic principles of good citizenship that no engineer, however busy, can conscientiously evade. If something akin to the engineering approach could pervade the councils of government, labor and business, then repetitions of the strikes, the slowdowns and the fumblings which have characterized the first full year of "peace" would undoubtedly become less frequent and might be entirely avoided.

DESIGNS OF THE MONTH

Motor Scooter Uses Only Two Controls

OPERATION of this motor scooter by two controls—a foot accelerator and brake—is made possible by the incorporation of an automatic clutch and automatic transmission having infinitely variable speed ratios from 4 to 1 to 16 to 1. The clutch engages smoothly and easily at approximately 1600 rpm and also disengages smoothly for idling. Use of this clutch eliminates possibility of stalling the engine through overloading. A 6-hp, single-cylinder, four-cycle, air-cooled engine is used, featuring straight-shot carburetion and forced-feed lubrication, not heretofore found in engines of this size. The engine, clutch and transmission is three-point rubber mounted, providing a floating suspension to absorb vibration. Chain drive is direct to the rear wheel.

Latest automotive practice is employed in the construction of the chassis which is pressed steel channel, spot welded, with preformed cross members. Body panels are press-formed and require a minimum of reinforcing. Flooring is sheet metal with an overlay of rubber matting. Welded aircraft-type construction is used in the front fork, road shocks being cushioned on direct-acting helical springs. Alignment in the fork is provided by a closely fitted sliding spline. Because the fixed portion of the spline is rigidly mounted in the front body cone, complete spring action is permitted without reaction on the handle bars. Wheel suspension is from one side only, and demountable rims are provided, making tire changing easy and quick.



Rear wheel is mounted on a pressed steel rocker arm, pivoted from a point on the frame and supported by a

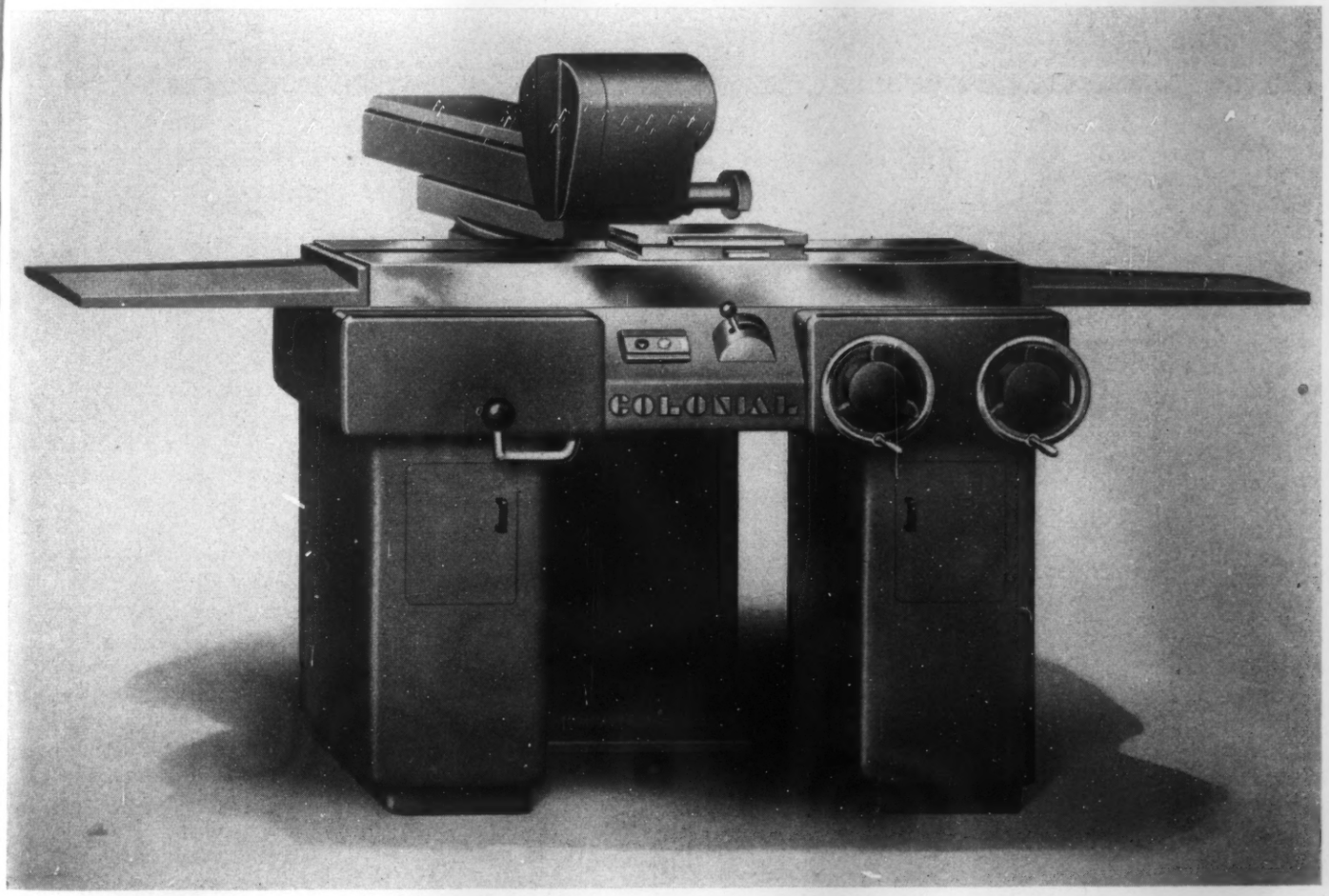
direct-acting helical spring. This wheel, like the front wheel, is side mounted for easy removal. Its brake is the internal expanding type with almost 22 square inches of braking surface. Both wheels are equipped with two tapered roller bearings. A built-in flywheel-type generator is provided for the front and rear lights. Manufacturer: Salsbury Motors, Inc., Pomona, Calif.

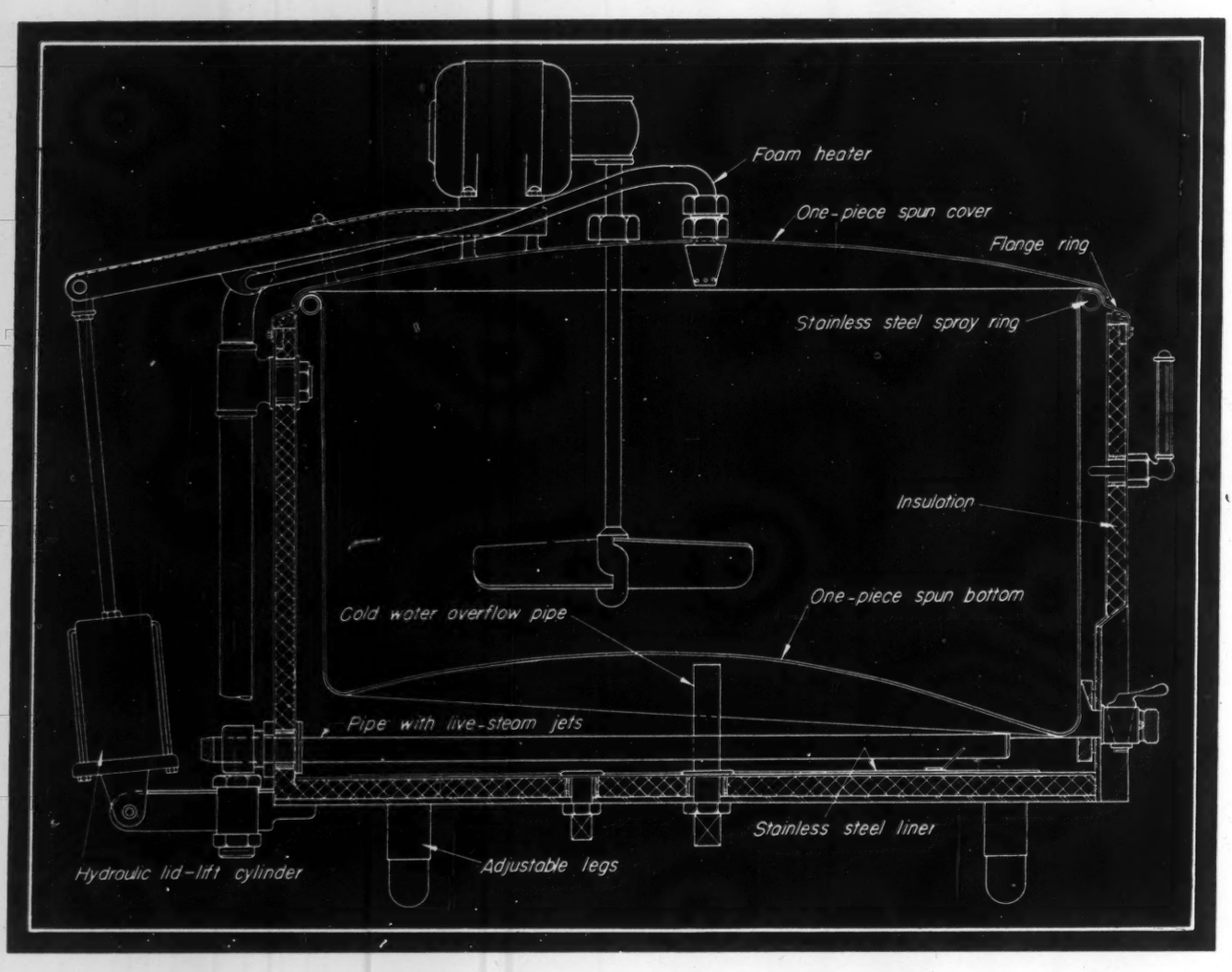
Operator Convenience Featured in New Broach Sharpener

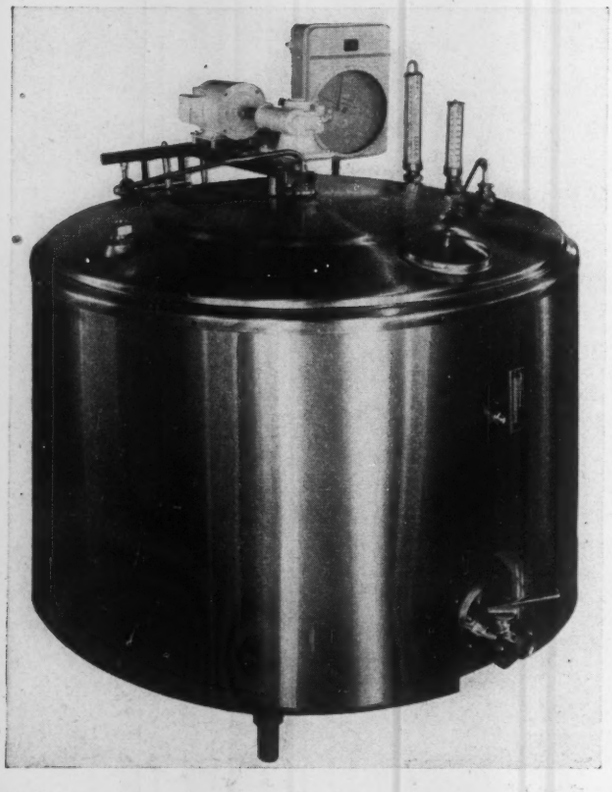
WITH this new machine an operator can sharpen flat surface broaches several feet long while comfortably seated and relaxed. Thus, operator fatigue is reduced and production increased. To permit the operator to sit close to the machine, the base is constructed of three pedestals. Two of these support the table at each side, forming a deep kneehole at the back of which is the third pedestal supporting the grinder head. Two handwheels, for controlling lengthwise movement of the table and for raising and lowering the grinder head, are located at the right side of the kneehole rather than at the center of the machine. The operator can reach them conveniently in these positions and can lean close to the machine without interference.

Main operating control of the machine is the lever at the left, with which the grinding wheel is moved back and forth across the face of the broach teeth to sharpen them. This lever is mounted within easy reach of the operator. Furthermore, it is adjustable up and down, in and out, and radially, so that the operator can set it to the most comfortable operating position. To ease operation further, the cross-slide which carries the grinder head is light in weight and is mounted on ball bearings at both top and bottom. With this construction sliding friction is reduced to a minimum.

Start and stop buttons and a magnetic-chuck switch lever are located in the front center of the machine, but in such a manner as not to interfere with the operator's position, although they are quickly and easily accessible. The design also increases safety because the operator is not required to reach across the machine to make the various control adjustments. Manufacturer: Colonial Broach Co., Detroit 13.







Pasteurizer Employs Hydraulically Actuated Cover

FUNCTION of this machine is to heat milk to pasteurizing temperature with live steam, shut off all steam during the holding period, and then cool to the desired temperature with cooling water. When heating, steam is fed in at the bottom of the space between the inner and outer chambers through jets in a long straight pipe. Cooling is effected by means of a spray of water from jets in a spray ring around the top of the machine. This method provides a thin film of water flowing over the surface of the milk tank, thereby assuring a maximum amount of heat absorption by the water. Noteworthy design feature of the machine is its flange ring, which joins the milk tank to the outside of the jacket. This ring provides a recess for the spray ring, an excellent seal seat for the cover flange, and, in addition, presents no exposed sharp edges.

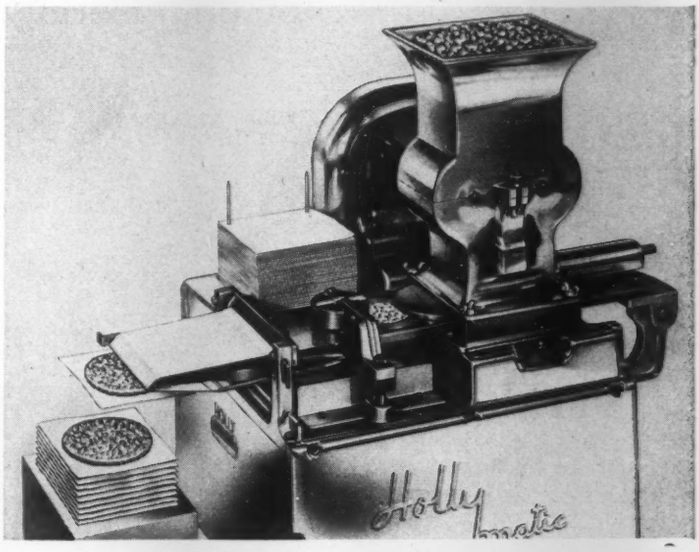
A hydraulic lift opens and closes the cover by water pressure, requiring no exertion on the part of the operator. The lift also eliminates the necessity of a latch to hold down the cover as is the case with counterbalanced covers. Agitator employed draws milk from the top wall of the tank and forces it downward and inward to the bottom, providing rapid and

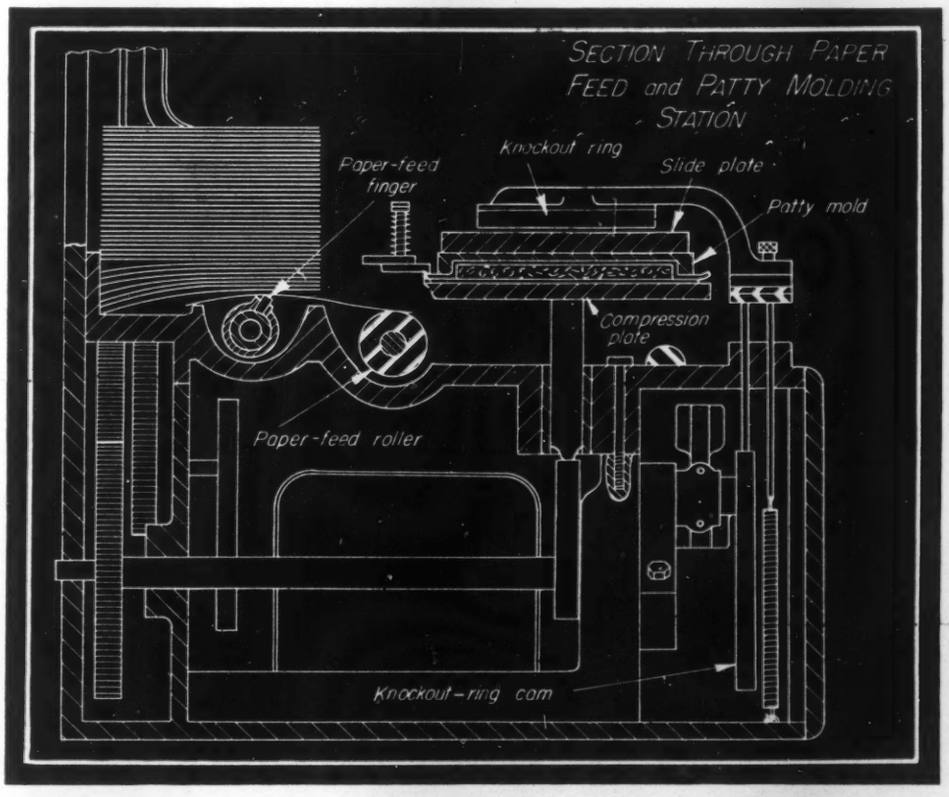
uniform heating. Steam pressure cannot build up because an open breather-type steam vent is employed. Machine has adjustable legs the threads of which are completely concealed for sanitation. Fiberglas insulation is used throughout between the walls of the outer chamber.

All major parts of the pasteurizer are stainless steel. Its one-piece cover is spun stainless with a center step to impart extra strength and rigidity. Manufacturer: Sterline Dairy Equipment Division, Steel and Tube Products Co., Milvaukee 1.

Hamburger Patty Molding Machine

THIS machine automatically measures, molds and stacks 1800 hamburger patties per hour. Ground meat is fed from the hopper into a hole in the slideplate which, being driven from a crank through two links and a pushrod, carries the meat forward into position under the knockout ring (see sectional view). Meanwhile a sheet of paper has been fed onto the compression plate. The knockout ring, driven by a cam, then moves suddenly downward and up again, pushing the disk of meat out of the hole in the slideplate and down onto the paper on the compression plate immediately below. As the slideplate then moves back again, the transfer belt is pulled over the lower face of the patty mold, the mold being fastened to the underside of the slideplate. Next, the compression plate rises, forcing the meat up into the mold, and then quickly lowers, leaving the formed patty adhering to the bottom side of the transfer belt and the paper adhering to the bottom side of the patty.



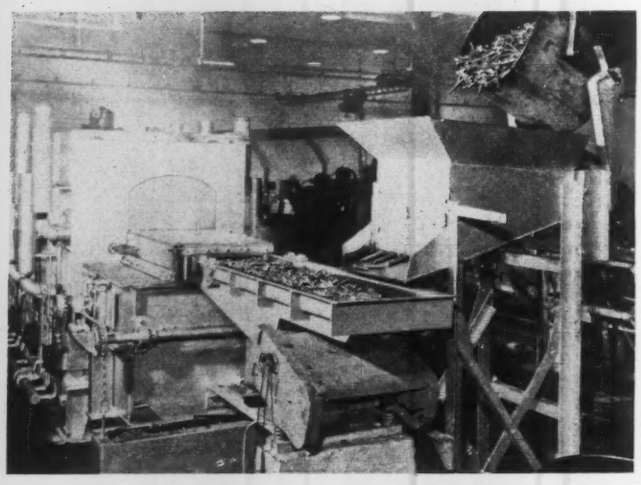


The transfer belt is fixed at its forward end to the machine frame and held at its rear end by leather laces which slide over smooth hooks on the slideplate sides. Thus, as the next cycle begins, the sideplate, as it moves forward, rolls the transfer belt over its rounded end and, as the completion of the forward stroke of the slideplate is reached, the patties shear off the belt and fall of their own weight onto a uniform pile. Hopper and housing of this machine are made of aluminum alloy, highly polished. The motor employed is ¼-hp, 110-volt, 60-cycle. Manufacturer: Holly Molding Devices, Chicago 37.

DESIGNS OF THE MONTH

Applications

of engineering parts, materials and processes

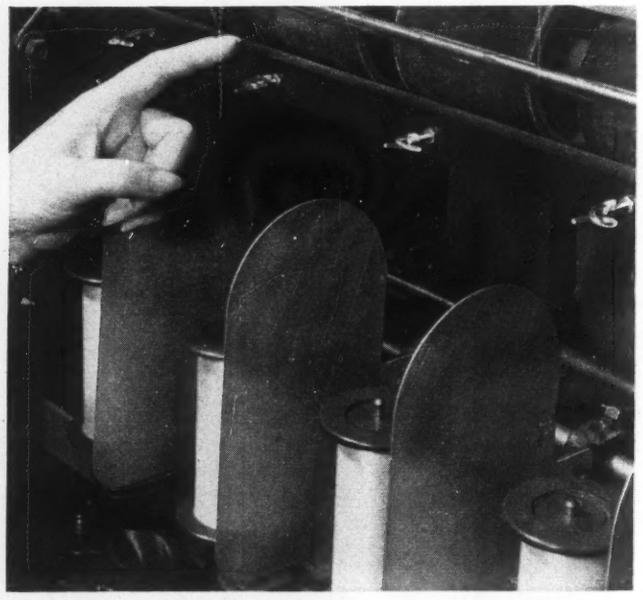


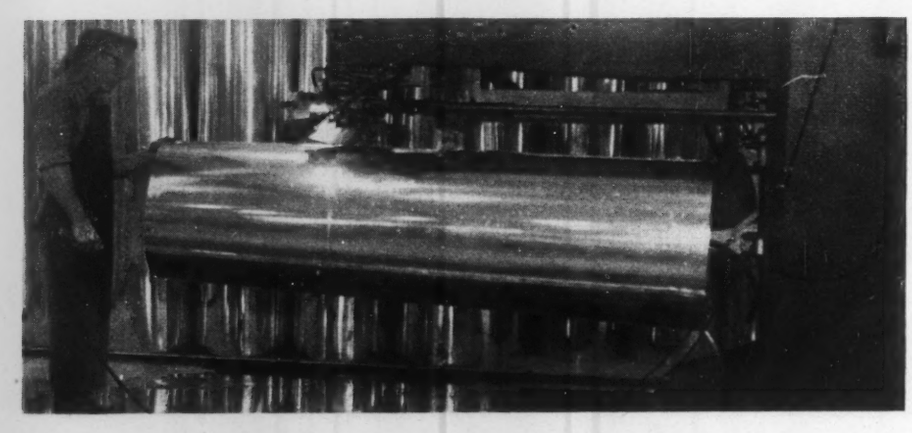
Solves Feeding Problem

CONTINUOUS FEEDING of small parts or powders, always a considerable problem, is conveniently accomplished by use of a Syntron vibrating unit, shown feeding bolts into an oven in the illustration, above. Energized by a pulsating current, an electromagnet pulls the material-carrying trough sharply down and back. Leaf springs then return the trough to its original position. The material in the trough falls perpendicularly as the trough is pulled from under it, then as the trough is returned to its original position by the springs, the material is carried forward. Thus, small parts may be caused to flow like water at a speed which is proportional to the force imparted by the magnet. Feed can be controlled from the finest trickle to a rushing stream.

Jeweled Thread Guides Have Long Life

ABRASION caused by high-speed feeding of thread in textile machinery rapidly cuts grooves in guides of ordinary materials. Long before a worn guide causes the thread to break, sufficient damage has been done to produce miles of defective fiber. Use of synthetic saphires made by The Linde Air Products Co., as shown in illustration below, has reduced guide replacement many fold. The hard surface resists wear, and the high polish resists the accumulation of lint.





Welding of Deep-Throated Parts

SEAM WELDING of long tubular parts has been rendered easy by use of a deep-throated seam welder, left. Shown is the automatic welding of a 94-inch long aluminum tail pipe for a P-80 jet plane. Thomson welder is controlled by hand switch at end of long cable, enabling operator to work unassisted.

How To Select Wear Resisting Alloys for Welding

By Joseph A. Cunningham
President
J. A. Cunningham Equipment Inc.
Philadelphia

TEN factors should be considered when choosing hard-surfacing electrodes or rods: (1) Severity of abrasion, (2) type of impact, if any, (3) rewelding worn hard-surfacing deposits, if necessary, (4) size of part to be surfaced, (5) thickness of deposit required, (6) composition of base metal, (7) work hardening encountered after welding, (8) corrosion, if any, (9) heat present or created, if any, (10) subsequent heat treatment or machining after welding, if necessary. The table on the following pages presents basic information concerning a variety of hard-facing alloys.

Abrasion can be considered as twofold: (1) Sliding abrasion, i.e., abrasion resulting from one material sliding over another, e.g., sand slipping past an agitator paddle, wire passing through guides in a steel mill, etc.; (2) rolling abrasion, e.g., crane wheels rolling over crane rails, gear teeth meshing against each other, etc. These two types of wear call for different hard surfacings—sliding abrasion requiring a hard wear-resistant alloy and rolling abrasion requiring less wear resistance but usually a tougher alloy. To resist sliding abrasion, choose a hard alloy in which the hard particles are imbedded in a tough-hard matrix. To resist rolling abrasion, the matrix between the hard particles need not be especially wear resistant.

To withstand severe sliding abrasion, choose either of the following: (a) A cast hard surfacing instead of a drawn one, or one which will produce a like deposit, that is, one of the harder groups usually containing carbon ranging from 2 to 3½ per cent in the weld deposit; (b) a composite hard surfacing composed of synthetic crystals, borides, carbides, etc., held in a tube; this is frequently referred to as tube metal. Composite hard surfacings, as welded, should contain a tough, hard matrix which will not wash away and leave the hard protruding particles unprotected, and hence subject to shear breakage.

Impact may be considered in two groups: (1) Edge impact and heavy compression, and (2) flat impact. Edge impact might be compared to the impact on the edge of a chisel while heavy compression might be compared to the impact encountered on a railroad track. These two conditions require approximately the same toughness in a hard surfacing. Flat impact implies a blow without accompanying heavy compression normal to a surface, such as might be encountered between a cement mill roll and die ring where the crushing force is normal to the die ring but the load is never tremendously large. Another example of flat impact would be very coarse gravel containing rocks passing through a large pump shell casing. In these instances of flat impact there is no concentrated wear or impact on the edges—neither is there extremely heavy compression.

To resist flat impact when severe abrasion is present, choose a cast electrode or one with great hardness and wear resistance. To resist edge impact, choose a hard surfacing with a high tensile strength. This will generally necessitate selecting a drawn hard surfacing and one which will contain less than 1½ per cent carbon in the weld deposit. Obviously, when the carbon content in the rod is in excess of 1½ per cent, the hard surfacing must be cast, since it is not practical to draw, roll or extrude steel with excessive carbon. Hence, for severe edge impact or heavy compression, choose a drawn hard surfacing—however, do not choose a drawn hard-surfacing electrode with excessive hardening alloys and high carbon added in the coating.

How To Minimize Spalling

Often two layers are applied, one superimposed over the other. It has been found that if too much carbon is present in the deposit, a second layer of like material superimposed over the first may cause some of the carbon to precipitate out of the solution and form a brittle carbide between the layers. This condition is not noticed until one-third to two-thirds of the first layer is worn away. Then if any impact is encountered, spalling occurs, i. e., one layer shells off in spots at the fusion zone between layers. Spalling can be minimized by selecting an electrode giving 2¼ per cent maximum carbon content in the weld deposit. Hardness and wear resistance can be obtained through the addition of other elements, or by using a hard-surfacing electrode composed of synthetic crystals imbedded in a tough, hard matrix.

Spalling may also be due to the selection of hard surfacing too low in tensile strength, i. e., without sufficient strength to resist the battering that takes place, for example, in a cement mill. Also, spalling may result from the use of a hard surfacing without adequate tensile strength to resist the combination flexing and pounding encountered on quarry screens, etc. For example, ordinary gray cast-iron rods applied with the arc produce a hard wear-re-

From a paper presented at the recent annual meeting of the American Welding Society in Atlantic City, N. J.

ENGINEERING DATA SHEET

Composition	RESISTANCE TO: Abrasion (†)	Erosion	Corrosion	IMPACT: Flat	IMPACT: Edge	Heat	Thermal Shock	Applied By	HARDNESS: Rockwell C	HARDNESS: Brinell	Tensile Strength, Psi.	Elongation, %	R.A., %	Uses	Price per Pound
Diamond hard synthetic granule and alloys in steel tube. Bond composition: Chromium . 30% Moly. ..... 8% Cobalt .... 8% Boron .....0.05% Tungsten .. 5% Carbon 0.20%	0.10	E	F	E	E	E	E	O-A	Granule 98 Bond 60	Granule 1000 Bond 610	Granule 300,000 Bond 200,000	Granule None Bond 15%	Granule None Bond 8	Extreme wear resistance. Coal-cutter bits, grader blades, scarifier teeth, shovel teeth, plow shares, conveyor screws, dredge heads, fish tail bits, rock and roller bits.	Oxyacetylene only. All sizes $5.50.
35% Tungsten 16% Moly 8% Cobalt 0.05% Boron 0.10% Carbon	0.20	F	G	E	G	E	G	Arc	65	675	225,000	Nil	Nil	High resistance to wear, heat, shock.	1/4 in. ....$4.50 3/16 in.... 4.50 1/8 in..... 5.40 Not recommended for oxyacetylene.
Nonferrous chrome-moly. and copper crystals. Chrome.. .....35% Moly. ..... 5% Crystals .....60% Crystal Size—1 micron.	0.25	E	E	E	F	G	G	O-A Arc	59 58	600 590	100,000	Nil	Nil	Excellent wear, corrosion, heat resistance. Plows, grinding rings, screw conveyors.	5/16 in....$1.75 1/4 in..... 1.90 3/16 in.... 2.00 5/32 in.... 2.75 1/8 in..... 2.75 Deduct 25c per pound for oxyacetylene rod.
Chrome .....35% Moly..... 10% Tungsten .. 8% Cobalt..... 6% Copper .... 14% Boron.....0.02% Carbon....0.60%	0.25	E	E	E	E	E	E	O-A Arc	58 56	590 560	115,000	3%	Slight	Special alloy for all valve faces. Automobile, Diesel, airplane, high pressure steam, poppet, blow down, plug and gate, corrosive liquid.	3/16 in....$3.50 1/8 in..... 4.00 For oxyacetylene, atomic - hydrogen, heliarc or arc welding.
High chrome, low moly. with boron and titanium in iron base. Carbon....0.20%	0.35	F	F	E	E	F	E	O-A Arc	55 55	540 540	185,000	2%	35	General purpose, shock and abrasion forgeable, self-hardening. Dipper teeth, tractor sprockets, etc.	1/4 in. ....$0.50 3/16 in.... 0.50 5/32 in.... 0.58 1/8 in..... 0.65 3/32 in.... 0.75
15% alloy with chrome, moly., nickel and boron in an iron base. Carbon.. .....2%	0.45	F	F	G	F	-	-	O-A Arc	57 55	575 550	70,000	Nil	Nil	Outstanding low cost value for abrasion.	Coated. Shape—round. 5/16 in....$0.42 1/4 in..... 0.45 3/16 in.... 0.47 Deduct 8c per pound for bare rod.
Special wear-resistant alloy for Two-Tone process only. Analysis: Chrome.. ....12% Moly. ..... 2% Nickel ..... 8% Boron..... 1% Titanium .... 4% Carbon.. ..... 4%	0.50	F	F	G	F	-	-	Spec. Arc only "Two-Tone"	54	540	60,000	Nil	Nil	Used with a mildsteel electrode type A.W.S. E6010, E6011 in the Two-Tone process.	Bare, round, cast. 3/8 x 24 in. $0.25 1/4 x 24 in. 0.30
Special drawn steel wire for use in the Two-Tone process only. Analysis: Chrome ... 4% Nickel .... 6% Moly. ..... 2% Vanadium.. 3% Boron ..... 0.5% Carbon 1.25%	0.80	-	-	E	G	-	G	Spec. Arc only "Two-Tone"	45 to 50	450 to 500	78,000	Slight	2%	For rapidly depositing a high-grade, semi-ductile, high-carbon layer of metal in build-up of high-carbon steel parts of heavy machinery by Two - Tone process only.	Bare, round, drawn rod. 3/8 x 24 in. $0.55 1/4 x 24 in. 0.60
Special cast nickel-manganese filler rod for Two-Tone process only. Manganese. 30% Nickel ..... 10% Vanadium.. 2% Carbon....1.75%	0.45	G	G	E	E	F	F	Spec. Arc only "Two-Tone"	25 to 58*	250 to 585*	70,000	* See Note	* See Note	Abrasion with impact for rapidly and *safely* building up all cast and rolled nickel-manganese steels on shovel teeth, tractor treads, bucket lips, etc., by the Two-Tone process.	Bare, round cast. 3/8 x 24 in. $0.55 1/4 x 24 in. 0.60

E = excellent; G = good ;F = fair ;- = not outstanding; * = after work hardening.

† Abrasion factor is the approximate rate at which the deposit wears off due to abrasion compared to a mild steel abrasion factor = 1.00.

* Deposits are soft when deposited but impact hardens exactly like straight manganese cast steels or nickel content drawn or rolled manganese steel.

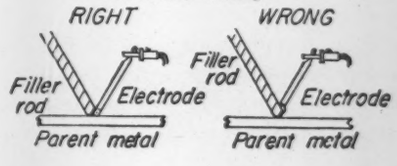
Flat impact is herein defined as a blow perpendicular to a flat surface. Edge impact is that type of impact normal to an edge or corner, e.g., on the edge of a cold chisel, shear blade or rail end. Extremely heavy pressures or extra heavy blows applied in any direction should be considered as having the same effect as edge impact.

ENGINEERING DATA SHEET

Appearance Color—Code Marks of Rods	Welding Characteristics	Amperes for Welding	Is Deposit Forgeable?	Response to Heat Treatment and Machinability	Increase in Hardness Due to Cold Working
Synthetic granule equally as hard as the white diamond secured in a specially alloyed tube containing definite proportions of chrome, moly., cobalt and boron metal powders which alloy with tube metal to form a very tough hard bonding to hold granule in place for work. 80 on 100 screen, nickel tube. 20 on 40 screen, copper tube.	Apply with oxyacetylene torch—deposits are fluid and bond to parent metal readily. Larger sizes can be used in the "Two-Tone" process with E6010 live electrode to obtain an extremely abrasion-resistant surface.	Oxyacetylene flame should be slightly carbonizing (excess acetylene). For "Two-Tone" process increase amp. 30% and use in conjunction with E6010 rev. polarity electrodes, E6011 or E6020 electrodes.	Yes—But forging has tendency to drive or bury particles into parent metal.	None	None
Particles in copper-coated steel tubes. Bare or with brown coating—green tip. Code—Green Tip.	Use reverse polarity d. c. or a. c. Apply in beads up to 3/4 in. wide. Use high amperes and hold long arc.	1/4 in.....200 to 300 3/16 in.....150 to 250 1/8 in.....100 to 150	No	Cannot anneal. Cannot machine.	Negligible
Cast. Black coating or bare. Code—Red Tip.	Use reverse polarity d. c. or a. c. Apply in beads up to 1 in. wide. Easy to use. Easy to apply with acetylene using decidedly carbonizing flame.	5/16 in.....250 to 350 1/4 in.....190 to 275 3/16 in.....150 to 225 1/8 in..... 80 to 130 Oxyacetylene. Use decidedly carbonizing flame.	Difficult	Cannot anneal. Cannot machine.	20 Brinell
Oxyacetylene—Cast. Ground finish. Code Color—Brown. Electrode—Cast. Dark Gray Coating. Code Color—Brown.	Use reverse polarity d. c. or a. c.—apply in beads 1 in. wide or less. Oxyacetylene—flows very freely with neutral flame. No flux required on steel.	Oxyacetylene. Use neutral flame. Electrode Amp. 3/16 in.....150 to 190 1/8 in..... 80 to 120	Difficult	Cannot anneal. Machinable with difficulty, use carboloy or kennametal tool. Grinding is best.	20 Brinell
Drawn wire. Yellow tip for electric welding. White tip for acetylene welding. Both are black coated.	Use reverse polarity d. c. or a. c. Can be applied with a wide weave in vertical position. A mineral-coated rod is used for acetylene welding.	1/4 in.....180 to 260 3/16 in.....140 to 190 5/32 in.....115 to 160 1/8 in..... 80 to 130 3/32 n..... 40 to 90	Yes	Cannot anneal.	30 Brinell
Cast. Black coating or bare. No color tip.	Use reverse polarity d. c. or a. c. Apply in beads up to 1 in. wide. Coated rod can be applied in vertical position. Oxyacetylene—use neutral or slightly carbonizing flame, flows freely	5/16 in.....240 to 340 1/4 in.....190 to 300 3/16 in.....150 to 225 Increase amperage slightly for bare Flintype VH.	No	Not practical to anneal. Cannot machine.	Negligible.
Cast—Dark gray rod. Color Code—Orange both ends. Rod—24 in. long.	Designed as a filler rod for use by the Two-Tone process only. Use with E6010, E6011, E6020 or E7010 heavy coated electrodes as source of heat. *Use reverse polarity* or a. c. on E6011 and E6020 electrodes. Increase amperage 30%.	3/8 in. rod—use 1/4-in. or 5/16-in. live electrode. 1/4-in. rod—use 3/16-in. live electrode. Do not apply with carbon arc.	No	Not practical to anneal deposits. Cannot machine.	Negligible
Drawn wire. Color—Grayish-brown. Rod—24 in. long. No color tip.	Designed as a filler rod for use by the Two-Tone process only. Use with E6010, E6011, E6020 or E7010 heavy coated electrode as source of heat. Increase amperage 30% over normal.	Same as above.	Yes	Can anneal, machine and subsequently reharden.	Negligible
Cast—Light gray to bright nickel color. Color Code—Blue—both ends. Rods—24 in. long.	Designed as a filler rod for use by the Two-Tone process to give high quality nickel-manganese steel deposits of austenitic type. Use E6010, E6011 electrodes for best results as source of heat. Increase amperage on the electrode 30%—work fast.	Same as second above.	Not ordinarily. Deposits should be peened while hot but only about 1/4 as much as regular nickel manganese steel deposits.	Cannot anneal. Cannot machine. Deposits are the same as high-grade nickel-manganese steel of the austenitic type. 3-1/2 to 5 nickel. 11 to 14 manganese.	250 Brinell. Deposits impact harden like best grade of these steels.

Mistakes in Applying "Two-Tone"—and How to Correct Them.—Do not feed too much of the alloyed filler rod into the arc as this produces over-roll and decreases penetration which will result in spalling or flaking off of the weld metal. The welding electrode must be kept near the work (hold medium arc) just as though the "dead" rod were not being used. The electrode is tilted in the opposite direction than for ordinary welding so that a very small portion of the arc—15 to 30% of it—nips the edge of the filler rod. Use 30% excess amperage.

Two-Tone Welding



sisting surface, but the tensile strength is not high enough to resist shock, and rewelding over worn gray iron deposits causes a brittle zone between layers. The answer is to select a hard surfacing in which the tensile strength is great enough to withstand job conditions and one which does not contain excessive carbon.

For hard surfacing large areas, Two-tone welding has gained favor. Developed by the author in 1941 and used extensively during World War II for rapid rebuilding of hard-to-get tractor and shovel parts, Two-tone welding consists of using a 7/32, 1/4 or 5/16-inch E6010 or E6011 mild steel electrode in the holder while feeding into the arc an alloyed, high-carbon or cast-iron filler rod. Several types of auxiliary filler rods are available, e. g., resultant deposits can be obtained to simulate high manganese, high-carbon and hard high-alloy deposits. Two-tone welding is two to three times faster (arc time) than ordinary welding, since 30 per cent excess amperage is used on the live electrode to increase the burn-off rate, and the auxiliary or dead rod is fed in at the same rate per pound as the live electrode. Two-tone welding is especially recommended for rebuilding large areas such as those on tractor rollers, shovel tracks, cement mill die rings, roll heads, etc.

Approximate composition of the deposit is determined by taking one-half the sum of each of the ingredients in the auxiliary filler rod and the electrode. Since E6010 or E6011 electrodes contain practically no carbon or alloys, the weld deposit will contain approximately one-half the amount of all of the alloys present in the filler rod.

Generally Restricted to Ferrous Metals

Hard surfacing can be applied to practically all iron-base metals but cannot be readily applied to the nonferrous groups. Most hard-surfacing applications are applied to mild steel, medium-carbon steel or manganese steel. When electric welding, the dilution of weld metal with parent metal generally causes a lowering of the hardness. This is particularly true with some of the very heavily coated electrodes which have an arc similar to the E6020 electrodes, and hence penetrate deeply and increase dilution. This type of electrode is fast flowing, deposits a thin layer, and therefore the cure is to deposit two to three layers of the weld metal.

However, when hard surfacing cast iron and high-carbon steel, not only is the first layer hard, but since residual stresses in the weld metal tend to pull the whole hard-surfacing layer out of place, it is generally advisable to select a hard-surfacing weld metal which will check and hence relieve stresses in the weld metal. Almost all the harder grades will check when electrically welded on large areas of any type base metal.

When it is known that work hardening will take place after welding, an austenitic electrode can be used to advantage. An austenitic hard-surfacing electrode produces a comparatively soft deposit having a rockwell C hardness of 20 to 30. However, it is tough and when subjected to battering or heavy blows, the surface will harden up to 35 to 45 rockwell C, while the core will remain soft. Inasmuch as in many instances abrasion takes place before the surface is completely work hardened, this type of electrode should be chosen cautiously; one of the low-alloy inexpensive grades of hard surfacing which are hard all the way through as deposited may be tough enough to stand the impact, and will wear better in case work hardening does not take place before abrasion rips the surface away.

To withstand corrosion, it is necessary to know what acids or alkalies are to be encountered, their concentration and the approximate temperatures attained since hot concentrated acids eat metal away much faster than cold diluted mixtures. If sufficient data are not available, apply several layers of hard surfacing to a piece of stainless, Monel or other metal which is capable of withstanding conditions to be encountered, and immerse the sample a short time in the acid. Test results can be obtained more quickly, if necessary, by using higher temperatures. Manufacturers of hard surfacings frequently have corrosion data available. To withstand erosion—e.g., on a water wheel, stainless steel has been found satisfactory.

Resisting High Temperatures

In some instances the hard-surfaced part encounters high temperatures, for example, a drag link chain carrying hot cement clinkers, or pins used in tongs for lifting hot billets in a steel mill. Both conditions require a hard surfacing which will maintain approximately 80 per cent of its hardness at temperatures up to 1000 or 1500 F. To resist high temperatures, choose a hard surfacing that is not readily annealed by high temperatures. The hard-surfacing electrodes of this class generally either contain a high percentage of tungsten, or may be composed largely of synthetic crystals which resist high temperatures. Hardness data at elevated temperatures can be obtained from the manufacturer.

In tool steel welding it is often necessary to heat treat the die or tool after welding. In order that this can be accomplished properly, choose a tool steel electrode which will produce a deposit having the same heat-treating cycle as the parent metal. This does not necessarily imply that the analysis of the weld deposit should be identical to the analysis of the parent metal. Before welding, preheat to approximately 100 F below the draw range of the parent metal. If desired, the die can be annealed and machined after welding and subsequently heat treated to obtain the original hardness—although frequently this is not necessary, since grinding to shape is often satisfactory. The same is true for air hardening, water hardening or high-speed tool steels.

In general-purpose hard surfacing, sometimes it is necessary to machine the parts after hard surfacing. Generally these parts could be ground, but if necessary equipment is not available, or grinding is considered too expensive, choose either a hard surfacing which is soft enough for machining as-welded, or one which can be annealed for machining and subsequently rehardened. Very few of the hard-surfacing electrodes other than tool steel or low-alloy electrodes can be readily annealed for machining. Tool steel electrodes are usually a drawn type and are generally in the low-alloy classification. Electrodes for machining after welding without subsequent annealing are generally drawn electrodes producing weld deposits in the low-medium (0.30 to 0.40 per cent) carbon class. However, ordinary grades of stainless steel or certain grades of aluminum bronze could be considered in this class also.

MACHINE DESIGN'S

MATERIALS WORK SHEET

FILING NUMBER
9.03

Aluminum Alloy 75S

AVAILABLE IN: (AN-A-9)* Sheet and plate, unclad
(AN-A-10)* Sheet and plate, clad (Alclad)
(AN-A-11a)* Extruded shapes

*Army-Navy Aeronautical Specification numbers. AN-A-11a also covers the composition of forgings.

ANALYSIS:

Cu	Mn	Mg	Zn	Cr	Al
1.6	0.2	2.5	5.6	0.3	Balance†

†Aluminum and normal impurities constitute balance.

PROPERTIES

TENSILE STRENGTH
(*psi*)

Form	Thickness (inches)	Tensile Str.
Sheet and Plate		
75S-O	0.016-0.500	40,000 max
75S-T	0.016-0.039	76,000 min
	0.040-2.000	77,000 min
Alclad 75S-O	0.016-0.500	36,000 max
Alclad 75S-T	0.016-0.039	70,000 min
	0.040-0.499	72,000 min
	0.500-2.000	77,000 min
Extruded Shapes		
75S-O	All	40,000 max
75S-T	up to 0.250	78,000 min
	0.251-4.000*	80,000 min
Rolled Rod and Bar		
75S-T	up to 3.000	77,000 min

*Strength given applies to sections of 20 square inches maximum cross-sectional area.

YIELD STRENGTH
(0.2% *offset, psi, min*)

Form	Thickness (inches)	Yield Str.
Sheet and Plate		
75S-T	0.016-0.039	65,000 min
	0.040-2.000	66,000 min
Alclad 75S-T	0.016-0.039	60,000 min
	0.040-0.499	62,000 min
	0.500-2.000	66,000 min
Extruded Shapes		
75S-T	up to 4.000*	70,000 min
Rolled Rod and Bar		
75S-T	up to 3.000	66,000 min

*Strength given applies to sections of 20 square inches maximum cross-sectional area.

ELONGATION IN 2 INCHES
(*min, per cent*)

Form	Thickness (inches)	Elong.
Sheet and Plate		
75S-O	0.016-0.500	10
75S-T	0.016-0.039	7
	0.040-0.500	8
	0.501-1.000	6
	1.001-2.000	4
Alclad 75S-O	0.016-0.500	10
Alclad 75S-T	0.016-0.039	7
	0.040-0.499	8
	0.500-1.000	6
	1.001-2.000	4
Extruded Shapes		
75-S-O	All	6
75S-T	up to 4.000*	6
Rolled Rod and Bar		
75S-T	up to 3.000	6

*Elongation applies to sections of 20 square inches maximum cross sectional area.

PHYSICAL CONSTANTS

Weight (lb/cu in.)		0.101
Melting Point, liquidus (deg F)		approx 1180
	solidus (deg F)	approx 890
Coef. of Thermal Expansion, annealed mat'l.		
(per deg C)	20 to 100 C	0.0000232
	20 to 200 C	0.0000242
	20 to 300 C	0.0000260
Coef. of Thermal Expansion, fully heat treated mat'l.		
per deg C)	−60 to +20 C	0.0000216
	20 to 100 C	0.0000236
Specific Heat at 100 C (cal/gm)		0.2297
Latent Heat of Fusion (cal/gm)		93.0

MACHINE DESIGN is pleased to acknowledge the collaboration of Aluminum Company of America in this presentation.

PHYSICAL CONSTANTS (Cont'd)

Thermal Conductivity at 25 C, fully heat treated mat'l. (cal/cm²/cm/deg C/sec)	0.29
Volume Conductivity, fully heat treated mat'l. (per cent of standard copper)	30
Electrical Resistivity at 20 C (microhms/cm)	5.747
Modulus of Elasticity in Tension (psi)	10,400,000
Torsional Modulus of Elasticity (psi)	3,900,000

PROPERTIES OF 75S-T AT ELEVATED TEMPERATURES

(after prolonged heating at testing temperatures)

	Temperature (Deg. F)					
	75	300	400	500	600	700
Tensile Strength (psi)	82,000	28,000	14,000	11,000	8,000	6,000
Yield Strength (psi)	72,000	22,000	11,000	8,000	6,000	4,000
Elong. in 2 In. (per cent)	11	32	55	60	68	75

CHARACTERISTICS

This heat-treatable aluminum alloy is approximately 90 per cent aluminum with magnesium, zinc and copper the major alloying ingredients. Stronger than aluminum alloy 24S, it was introduced during the war for use in the construction of military planes. Whereas 24S-T attains its maximum strength after one to four days of aging at room temperature, 75S-W continues age-hardening for an indefinite period of time, and attains its maximum strength after artificial aging.

APPLICATIONS

Having high strength plus light weight and good corrosion resistance, 75S in both sheet and extruded forms is particularly applicable to structural parts in aircraft. Other applications include structural parts on various types of portable and mobile machines which require good strength plus light weight.

FABRICATION

In general, tools should have appreciably more side and top rake than are required for cutting steel; in fact, their shapes approximate more closely those used for cutting hard wood. In addition, cutting tool edges should be maintained extremely keen and smooth. Twist drills with large spiral angles generally are preferred. Best results usually are obtained by using comparatively high speeds and fine to medium feeds; the finer the feed, the higher the speed. Use of a lubricant is desirable and it should be used copiously. For general use, a mixture of kerosene and lard oil is satisfactory as a cutting compound, and for milling, sawing and drilling, the more economical soluble cutting oils may be used.

FORMING:

This alloy, after solution heat treatment and artificial aging (75S-T or Alclad 75S-T), does not form as readily as alloy 24S-T. In the solution heat treated and quenched condition, however, 75S has somewhat lower strength and a longer period of delayed aging at room temperature than freshly quenched 24S (about one hour as compared with 10 to 15 minutes for 24S), so that more difficult forming operations are possible in this condition on 75S than on 24S. The alloy may be retained in this condition of optimum formability for at least a week if it is refrigerated at 0 F immediately after quenching. In the annealed condition 75S-0 is about as formable as 24S-0. 75S-T parts can be heated for about an hour at 350 F to permit hot forming without materially reducing their strengths or adversely affecting their resistance to corrosion.

WELDING:

Torch welding of 75S is not recommended. Arc welding of 75S is possible on material thicker than about 5/64-inch but is accompanied by a considerable loss in strength if the material is in the heat-treated condition, and by a decrease in corrosion resistance. Although the loss in these properties can be recovered partially by reheat treatment of the welded assembly, the properties of the welded joint are still inferior to those of a well-designed mechanical type of joint.

Spot welding of Alclad 75S-T sheet can be performed satisfactorily with equipment in general use in the aircraft industry. However, it requires more tip pressure, flatter tip contour, and narrower ranges of mechanical settings than does Alclad 24S-T. Cleaning is necessary before spot welding, and can be done with steel wool or a wire brush. For chemical cleaning, a nitric acid hydrofluoric acid cleaning solution is satisfactory. Strengths of properly made spot welds are about the same as those of Alclad 24S-T.

RIVETING:

Joining of 75S sheet and structural shapes most often is effected by riveting. Rivets of aluminum alloys A17S-T, 17S-T, 24S-T or steel are recommended, steel rivets being limited to applications where the structure can be protected adequately by painting. Rivets of A17S-T always are furnished in the heat-treated condition and are driven cold, as-received. They may be stored indefinitely at room temperature with no change in properties. Alloy 17S rivets always are heat treated to obtain maximum strength before using. Heat treatment consists of holding the rivets at 930 to 950 F from five to thirty minutes, depending on size and quantity of rivets treated, followed immediately by quenching in cold water. They generally are used within a few hours after quenching, else age hardening makes them too hard for satisfactory riveting. Storing them in a cold chamber (32 F or under) will retard age hardening.

Alloy 24S rivets are handled much like 17S-T rivets except that the heat treating range is from 910 to 930 F and the total time at room temperature between quenching and driving should not exceed about ten minutes. Storage at low temperature to retard hardening is even more important with 24S rivets than with 17S rivets.

In general, the diameter of rivets should not exceed two and one-half to three times the thickness of the sheet or plate, nor should their diameter be less than the thickness of the thickest plate through which they are driven. Recommended minimum spacing is three times the nominal rivet diameter and maximum spacing should not exceed twenty-four times the thickness of the sheet or plate. For maximum bearing strength, the edge distance measured from the center of the hole in the direction of stressing should be at least twice the diameter of the rivet hole.

Rivet holes may be drilled, or sub-drilled and reamed to size, the last mentioned method being preferable, particularly when reaming is done in assembly to insure exact coincidence of the holes. The best clearance between rivet and hole is the smallest one which will allow the rivet to be inserted easily without delay.

Flush riveting in 75S-T alloy can be accomplished either by

machine countersinking the rivet holes or by dimpling the sheet to receive the countersunk head of the rivet. If the latter procedure is adopted, it is essential that the dimpling be done with special tools in order to avoid cracking the sheet. Heated tools have been found effective. The tool temperature required is a function of the interval of time that the tool is in contact with the sheet and usually must be determined experimentally. The best tool temperature is the lowest one which will produce crack-free dimples for the speed of dimpling used.

HEAT TREATMENTS

Annealing: 75S in either the heat-treated or cold-worked conditions may be fully annealed by heating for 2 hours at from 775 to 850 F, air cooling and reheating for 4 hours at 450 F. Under certain conditions—it, for example, forming is to be done immediately after annealing—75S may be slowly cooled at a rate not exceeding 50 F per hour to room temperature and the treatment at 450 F omitted. It should be pointed out, however, that the properties of such material will vary with the rate of cooling. The more rapid the rate of cooling, the higher the strengths that will result.

Solution Heat Treatment: Sheet and sheet products usually are heated from 10 minutes to one hour (depending upon the thickness of sheet) at temperatures from 860 to 930 F and quenched in cold water. Extrusions and forgings are treated similarly except that the temperature range is 860 to 880 F. Very large forgings, however, are sometimes quenched in water at 150 to 212 F in order to minimize residual stresses.

Precipitation or Artificial Aging Treatment: Sheet and parts in as-quenched temper usually are heated from 4 to 6 hours at 310 to 320 F. This aging treatment was developed specifically for the purpose of improving the formability of 75S-T parts, particularly the dimpling characteristics of 75S-T sheets to be joined by means of countersunk rivets. It also improves the driving characteristics of 75S-T aircraft rivets. Extrusions, forgings and other products, however, are aged from 22 to 26 hours at 245 to 255 F. This treatment is also applicable to sheet products.

RESISTANCE TO CORROSION

Corrosion resistance of 75S-T is about on a par with that of 24S-T. While 75S-T does not corrode appreciably in dry, clean inland atmospheres, customarily it is protected with paint coatings, usually preceded by anodizing or chemical-dip oxide coating. In marine and highly contaminated industrial atmospheres, joint coatings preceded by anodic or other types of oxide treatments are recommeded. 75S-T is not as corrosion resistant as alloy 2S (commercially pure aluminum) or the silicon and manganese-bearing aluminum alloys. Alclad 75S-T, because of the electrolytic protection afforded by the alclad coating, has an inherently high resistance to corrosion and generally is used without benefit of paint coatings.

GALVANIC CORROSION

Contact of this alloy—as with other aluminum alloys—with copper, nickel, brass, bronze, Monel, iron and steel should be avoided in the presence of corrosive environments such as salt water or sea coast atmosphere, because these metals are cathodic to 75S-T and Alclad 75S-T, and the resulting galvanic couple results in accelerated corrosion. Zinc and cadmium-plated parts, however, can safely be used in contract with it.

CORROSION-RESISTANT FINISHES

Anodic coatings, which can be applied in various colors (by die or pigment absorption) provide good resistance to corrosion, have high dielectric strength and can be made hard so as to offer resistance to abrasion. For maximum corrosion resistance, anodic coatings should be sealed with a chromate or other sealer. Electroplated chromium finishes sometimes are applied where abrasion resistance is required.

MATERIAL DESIGNATIONS

Alloy	Form	Army and Army Air Forces	Army-Navy(AN) Aeronautical	SAE AMS
75S	Plate & Sheet		AN-A-9a-1	
	B. R, W and S	AXS-1641	AN-A-11a	4122, 4154
	Tubing, Round		AN-T-32	
	Forgings			4139A
	Forging Stock			4139A
Alclad 75S	Plate & Sheet	AXS-1649	AN-A-10b	

Maximum Commercial* Sizes of 75S and Alclad 75S Plates**

Thickness (inches)	Maximum Width (inches)	Maximum Length for Maximum Width Inches	Maximum Length for Maximum Width Feet	Maximum Length (feet) for Indicated Widths Widths 43 in. or less	Width 60 in.	Width 72 in.	Width 84 in.	Width 96 in.
¼	72	360	30.0	30.0	30.0	30.0	...	...
⅜	84	348	29.0	36.0	36.0	33.9	29.0	...
½	62	288	24.0	36.0	31.0	26.0	...	...
⅝	49	288	24.0	34.0	25.0	...	...	...
¾	41	288	24.0	29.0	...	...	...	...
⅞	38	288	24.0	25.0	...	...	...	...
1	105	105	8.7	10.0	10.0	10.0	10.0	9.5
1¼	94	94	7.8	10.0	10.0	10.0	8.8	...
1½	86	86	7.1	10.0	10.0	8.4	7.2	...
1¾	79	79	6.6	10.0	8.7	7.3	...	...
2	74	74	6.2	10.0	7.6	6.3	...	...

* In some cases larger sizes can be produced by means of special manufacturing practices; requirements for larger sizes should be the subject of special inquiry. In many cases the maximum sizes listed are determined by available flattening equipment rather than rolling capacity, in which cases larger sizes may be produced in the soft (0) temper. These are not listed since these alloys are used almost exclusively in the heat-treated tempers. For thicknesses or lengths intermediate between those listed, available dimensions are in proportion within the limits of manufacturing equipment.

** The dimensions shown are subject to the following limitations:

(a) Maximum limit in length of plates in these alloys in the soft (0) temper is 30 feet.

(b) Maximum diameter of circles same as maximum width of plate.

(c) Degree of flatness that can be obtained depends upon the alloy and temper, and upon the dimensions of the plate. The maximum degree of flatness in these alloys in heat-treated tempers, in thicknesses over ½ inch, can be supplied in lengths up to 120 inches.

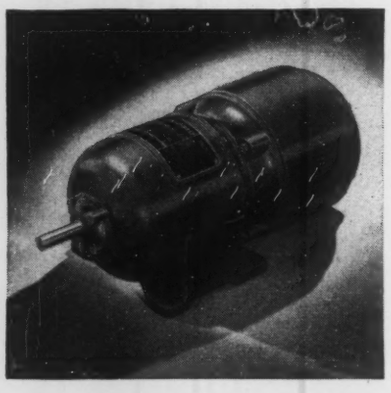
(d) Shearing: Unless otherwise specified, plates in all commercial widths of 6 inches or greater and in thicknesses up to 0.375 inch inclusive are sheared. Thicker plates or narrower widths must be sawed.

Plate circles 17½ inches diameter and larger in ¼-inch thickness are sheared, unless otherwise specified. The following sizes are sawed: Diameters 7½ to 17½ inches, thickness ¼ inch; diameters 7½ inches and larger, over ¼-inch thickness; diameters smaller than 7½ inches are special.

new parts and materials

Drive Unit

PACKAGED power unit comprising electric motor and hydraulic coupling has recently been announced by the Link Belt Co., 307 North Michigan Ave., Chicago 1. Known as the Electrofluid drive, the assembly consists of a general purpose induction motor flange mounted on a sturdy housing containing a fluid coupling. The output shaft may be direct-connected to the driven machine or to a speed reducer unit, it may also be connected to driven machine through the medium of chain, gear or belt drives. The unit has unique advantages because of the torque-speed characteristics. The drive motor starts at low load irrespective of load imposed on unit because at zero speed the torque transmitting capacity of the coupling is zero. Motor accelerates quickly developing torque in the fluid coupling in the ratio of the square of the speed until sufficient torque up to the maximum



capacity of the motor is developed to start the driven load. Should the driven machine be stalled, the drive will pull maximum torque capacity of the motor thereby drawing sufficient current to cause the thermal overload device to function within a few seconds. Coupling absorbs the energy of the motor rotor protecting driven machines from shock of the rotor's inertia under sudden stoppage.

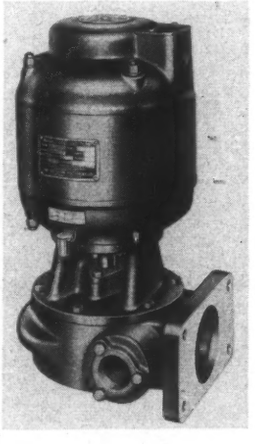
Dielectric Heater

USEFUL for heating of plastic preforms, a new electronic heater is announced by the Industrial Heating Division of the General Electric Co., Schenectady. The new heater features fast heating, simple operation and sturdy construction, and is designed for operation at 40 megacycles with a water-cooled oscillator tube. The unit makes possible the use of an average full-power 5-kw output during the entire heating cycle, is small to fit conveniently between two molding presses, and is able to accommodate the alternate operation of the two presses. All controls except pushbuttons are located behind the locked front door to prevent tampering. Heater is mounted on casters.

New Coupling

GEAR TOOTH principle is employed in a new flexible coupling being manufactured by the Industrial Machine Works Inc., South Hanover, Mass. Two identical end-pieces each having two diametrically opposed involute gear teeth, mate with a self-lubricating, sintered - bronze center-piece containing rack grooves which are mutually perpendicular. The design is said to provide simultaneous automatic correction for angular and parallel misalignment. The IMW couplings are suitable for high-speed applications, have a torque capacity to 1500 lb-in. Units are available in standard shaft sizes to 1¾ inches.

Coolant Pump



CLOSE-COUPLED, vertical-shaft pump capable of delivering 70 gpm has recently been announced by the Ruthman Machinery Co., 1811 Reading Road, Cincinnati 2. The unit may be installed above or below the reservoir in horizontal or vertical position. It can be converted to pipe-inlet type by use of a pipe-adapter plate available in several sizes. Known as Rumac Model 2-C, the pump will deliver fluid at a total head of 22 ft when equipped with a ¾-hp motor.

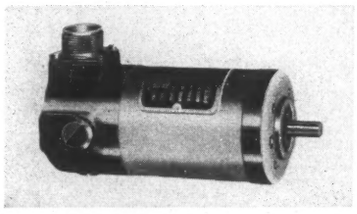
Silicone Resin

THERMOSETTING silicone resin has recently been developed by the Dow Corning Corp., Midland, Michigan.

The new resin, known as DC-804, is especially suitable for use in formulating white finishes having properties between those of ceramic coatings and ordinary organic paints.

These new paints do not become yellow or chalky with age because they have high resistance to moisture, oxidation, ozone and ultraviolet radiation. In addition, they are said to be exceptionally heat resistant and to provide a hard, mar-resisting surface.

Fractional-Horsepower Motors

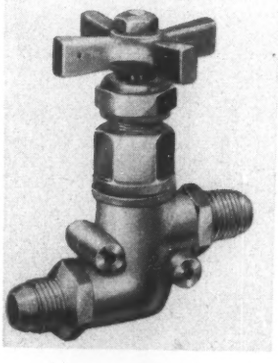


SPECIALIZED MOTORS built to precise demand and now available from Pesco Products Co., 11610 Euclid Ave., Cleveland 6, are based on a system of building units from standard parts. For a standard frame size, such as frame B, windings may be series, compound or shunt, shafts may be tongue, square, semiround, round or special; rating may vary in the range 0.02 hp at 3600 rpm to 0.215 hp at 10,000 rpm at 27 volts dc or other special voltages. The units have sealed-in bearings long-life brushes, and explosion-resistant construction.

Oil Seals

DEVELOPED by the Johns-Manville Corp., 22 East 40th St., New York 16, is a new type of nonmetallic oil seal for shafts from 1 5/16 to 37 inches in diameter. The new unit known as the clipper seal is made with a heel of resin-bonded fabric giving it the rigidity essential for a press fit in the cavity, and with a lip of a tough but flexible compound. A special lip design makes it possible to vary the bearing area and control the pressure of the lip against the shaft by means of a garter spring, thereby reducing shaft wear to a minimum. The seal has a one-piece precision-made body, concentrically molded and nonmetallic in construction. Its compact shape makes possible a light flange section effecting compactness of machine design.

Fractional-Inch Valves



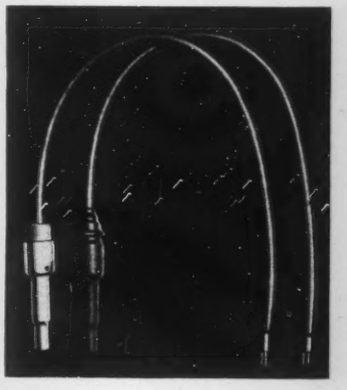
SERIES of industrial valves incorporating a number of design features have been announced by Parker Appliance Co., 17325 Euclid Ave., Cleveland. The new fittings are available in either needle or globe types in sizes up to one inch, in both angle and offset designs. Both types are available in six combinations of connection arrangements using female pipe threads, tubing threads or male pipe threads. The variations are said to enable the new valves to be direct connected to either pipe or flexible tube systems without the necessity of extra nipple adapters. Tubing is accommodated in a range from 1/4-inch to one inch outside diameter, pipe from 1/8 to one inch. All valves are provided with integral mounting lugs.

Light-Weight Plastic

EXPANDED PLASTIC applicable to many installation requirements has been announced by the Dow Chemical Co., Midland, Mich. The new material known as Styrofoam is styron expanded forty times. The expansion produces a pure white, light weight, multicellular mass of foam-like material with low thermal conductivity, good structural strength and very high moisture resistance. Styrofoam is tasteless, odorless and has good resistance to mold and rot. It shows no tendency to disintegrate or settle, an important factor in low-temperature insulation.

Thermostats

IMMERSION-TYPE thermostat designated Type M1 has been announced by United Electric Controls Co., 71 A Street, So. Boston, Mass. The unit, particularly designed for close temperature control on battery chargers, is applicable for controlling the temperature of strong liquids,

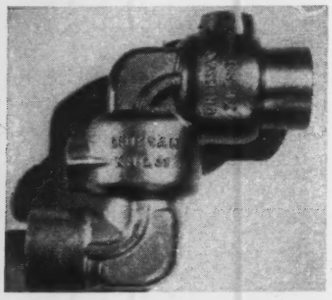


gases and hot plates. It is normally supplied with a neoprene sleeve which gives complete protection to the unit for applications injurious to brass. Thermostat is a sturdy, precision-built unit with electrical rating of 1000 watts at 110 volts ac, noninductive. The on-off differential is 3 degrees, and the control is adjustable within the range of 0 to 250F.

Swivel Joints

SWIVEL JOINT built for pressures up to 12,000 psi is announced by Chiksan Co., Brea, Calif. Rotating members are steel forgings machined to close tolerances and have flame-hardened ball races. Full 360-degree rotation with low torque takes place on two rows of hardened-steel balls which also serve to hold the rotating members together under preregulated pressure. The packing element is specially designed for high pressure service and is self-adjusting. The type XA joint employs no bolted flanges, locking rings or stuffing boxes, thus there is

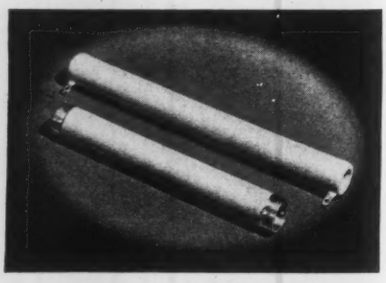
nothing to tighten or adjust. High pressure lubricating fittings provide for positive lubrication of the bearings. Inside diameter is unobstructed, permitting full flow of



liquids, gases and vapors with minimum friction loss and turbulence. End connections are of the high-pressure, tapered-thread type. Joint is recommended for high-pressure services to 12,000 psi where maximum flexibility, easy turning, minimum maintenance, long life and maximum safety are required.

Resistors

VITREOUS ENAMELED resistors known as Vitrahm "M" have been announced by Ward Leonard Electric Co., Mount Vernon, N. Y. The resistors meet all the requirements of U. S. Army and Navy specifications JAN-R-26 for characteristic "F". They are designed expressly for use on power type resistor applications where the severest operating conditions are encountered. These



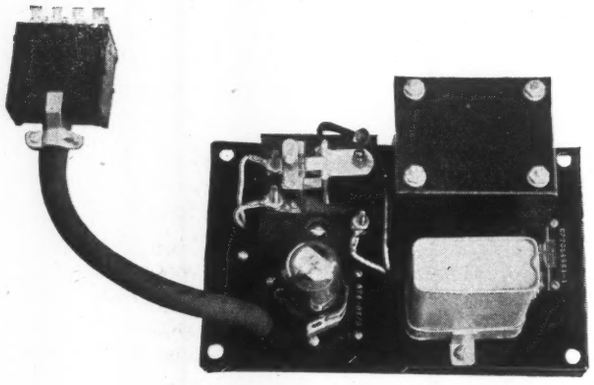
Grade 1, Class I resistors are available in ferrule, tab and screw terminal types with power ratings from 8 to 155 watts capable of operation continuously at 275 C. Resistant values are obtainable in sizes covered by the specifications, ranging from 0.1 to 80,000 ohms, with resistance tolerances for one ohm and above of plus or minus 5 per cent.

Alternators

DESIGNED for direct connection to either 720 or 900 rpm engines, two types of ac generators—8 and 10 pole—have been announced by Kato Engineering Co., Mankato, Minn. The 900 rpm alternators are available with direct-connected exciter or top-mounted exciter, while the 720 rpm generators are available only with top-mounted V-belt driven exciter, Generators are available in 2 and 3-wire single-phase types as well as 3 and 4-wire 2-phase types for voltage combinations such as 110-220 volts single phase, 120-208 volts, 3-phase, and 400 volts, 3-phase.

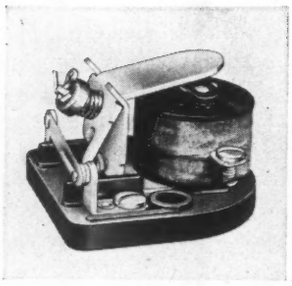
Magnetic Limit Switch

DESIGNED FOR tube thrust block or draw-bench carriage return applications, a new limit switch announced by Cutler-Hammer Inc., 315 North Twelfth St., Milwaukee 1, provides instantaneous performance under either slow or high speed operating conditions. Typical installation consists of one final and two slowdown magnetic limit switches for each direction of travel. Each switch consists of a separately mounted transformer and



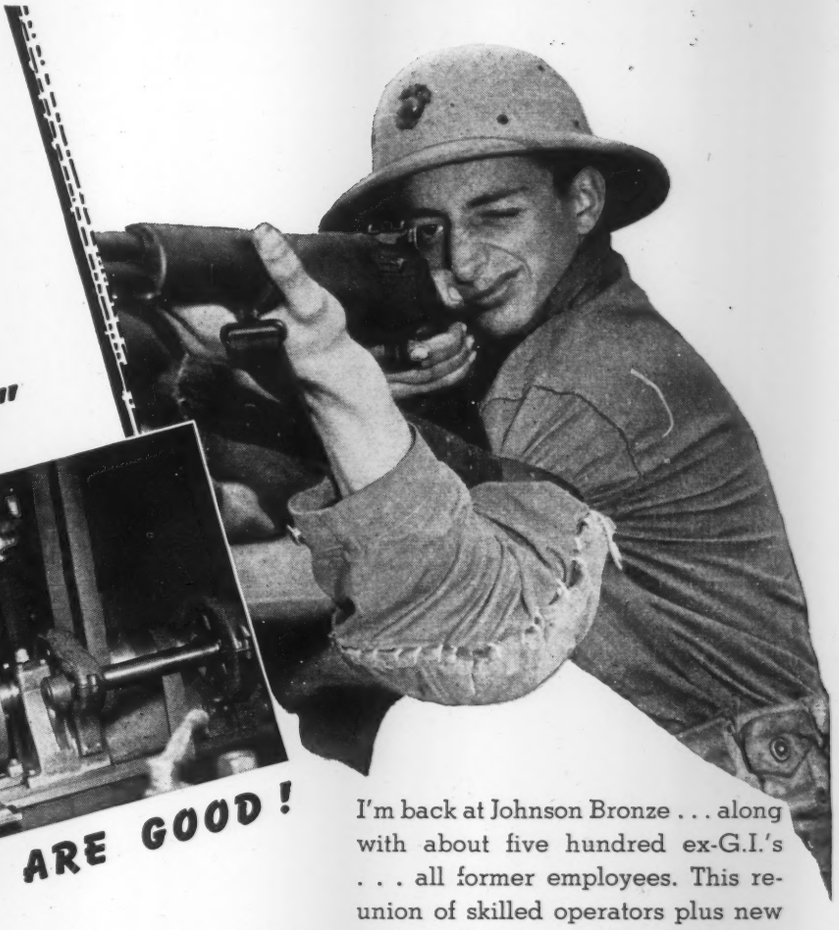
an electronic control unit mounted on the motor control panel. Transformers are slide-rail mounted to provide easy positioning on the job. This limit switch has been designed for operation with actuating plate speeds up to 4000 fpm and no adjustments are required for installation or maintenance. "Fail-safe" performance is assured since the control relay drops out immediately to stop the motor with any failure, short circuit or open circuit.

Motor-Starting Relays



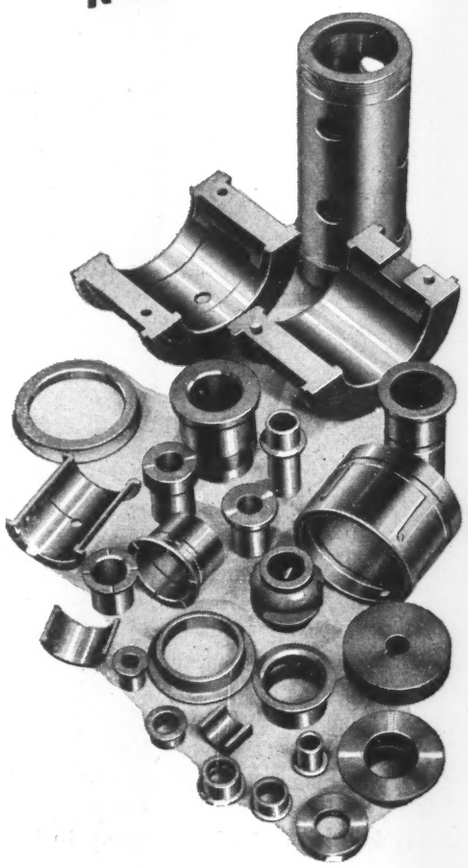
VOLTAGE ACTUATED relay for starting electric motors has been announced by Potter & Brumfield Sales Co., Dept. 232, 549 West Washington Blvd., Chicago 6. The device operates on the back emf of the starting winding, thus when motor has attained speed the relay immediately disconnects starting coil from line. Therefore no overload with attendant heavy-current flow can prevent the unit from successful operation once proper motor speed has been reached. The new

"I'VE TRADED MY GUN FOR MY OLD JOB"



NOW DELIVERIES ARE GOOD!

I'm back at Johnson Bronze . . . along with about five hundred ex-G.I.'s . . . all former employees. This reunion of skilled operators plus new and enlarged facilities has certainly stepped up production. Now we can make deliveries in a matter of weeks . . . not months. This is particularly true with cast bronze bearings . . . especially in the large sizes . . . made to your specifications. In standard stock items such as UNIVERSAL Bronze Bars, G. P. Bearings and Electric Motor Bearings, we can make deliveries the same day the order is received. Isn't this the type of service you appreciate? Why not give us the opportunity to prove our excellent delivery. Our bearings will prove their quality through extra performance and long life. Call your local Johnson Bronze Man TODAY.



JOHNSON BRONZE COMPANY
525 SOUTH MILL STREET NEW CASTLE, PA.

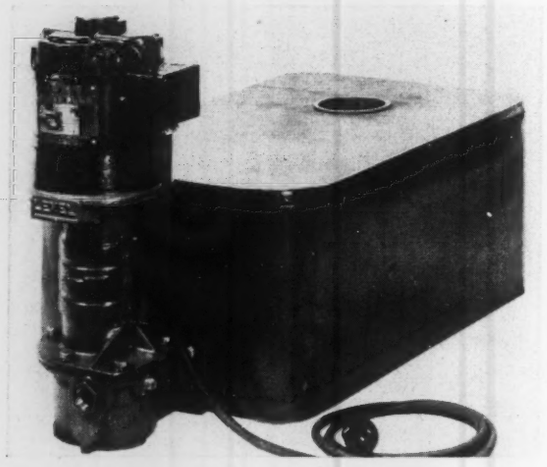
BRANCHES IN 18 INDUSTRIAL CENTERS

JOHNSON BRONZE
SLEEVE BEARING HEADQUARTERS

unit, MS2A, prevents burn-outs and makes a complete motor tear-down for repair unnecessary. The relay operates over a wide range of line voltage variations and is reliable on normally-low lines with their attendant heavier current flow. The relay is said to be especially applicable to motors which are inaccessible, such as sealed-in types. It also operates well on motors subjected to heavy accumulations of dust, dirt and grease.

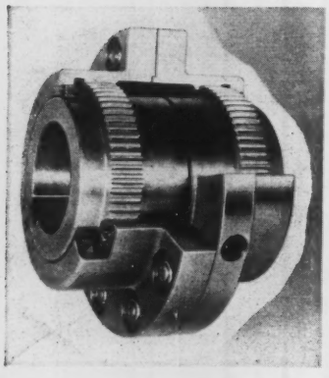
Coolant Pump and Tank

HIGH CAPACITY coolant pump and tank assembly has been announced by the Delta Manufacturing Division, Rockwell Mfg. Co., 600 E. Vienna Ave., Milwaukee 1. The unit, powered by a ¼-hp totally-enclosed motor, will de-



liver up to 30 gpm at low heads and 2 gpm at a 14-foot head. The 16-gallon steel tank is equipped with a settling basin and wire mesh filter screen to keep coolant free of chips. Several different catalog units are available to suit various electrical power sources.

Gear-Type Coupling



DESIGNED for a large maximum bore, thus permitting use of smaller sized couplings than ordinarily required, a new Series A coupling has been announced by John Waldron Corp., River Road, New Brunswick, N. J. The smaller size coupling takes up less space, needs less shaft extension, and has improved appearance. The unit retains all exclusive construction refinements basic in Waldron couplings, they are all steel, dust proof and oil tight, and have identical externally geared hubs that key to shafts enclosed by one piece male and female sleeves functioning in single rigid units. The coupling is said to compensate for misalignment without added stress to shaft or bearings.

Miniature Rotameter

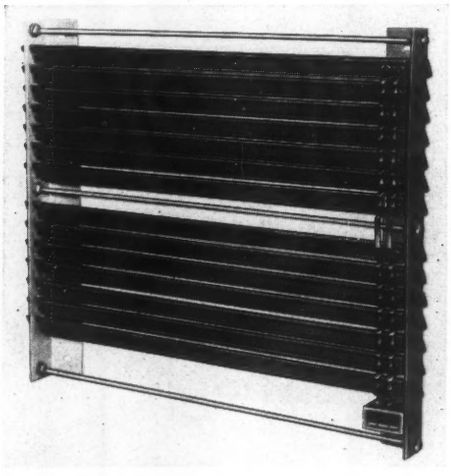
FULL-SIZE rotameters made as die cast units have been announced by Fischer & Porter Co., Hatboro, Pa. Designed for purge-line service the units are made in the capacity range of 0.2 to 2.0 standard cubic feet per hour of air when metered at 10 psi and 70 F (or 0.6 to 9.0 cc per min of liquid with a specific gravity of 1.0, viscosity 1.0 centipose). The meters include a red or black glass ball, indicating on a capacity scale etched in red.

Sintered Alnico Magnets

COMPLETE FACILITIES for engineering and producing sintered Alnico II in a wide variety of magnet sizes and shapes has been announced by Stackpole Carbon Co., St. Marys, Pa. Stackpole sintered Alnico II offers magnetic properties equivalent to those of the cast product. It has, moreover, advantages in uniformity characteristics and greater mechanical strength in weights up to 2 oz.

Oven Heater

ELECTRIC HEATER suitable for oven use is available from Edwin L. Wiegand Co., 7575 Thomas Boulevard, Pittsburgh 8. The unit assembly consists of four-



teen high-temperature chrome-steel-sheathed strip heaters giving a combined rating of 8 kw at 230 volts. End brackets of heavy sheet metal are punched to permit mounting to either walls or bottom of the oven. Strip heater elements are mounted in the end bracket at a slight angle to the

Boy-size weight with man-size strength

Magnesium

Producers of more and more consumer goods are realizing that magnesium gives their products not only a modern look but—more important—the modern *feel* of lightness. This sidewalk bike, for example, weighs 13 pounds. Its major part—the solid magnesium frame—is but 2½ pounds! Yet magnesium provides maximum strength—the ultimate durability people expect in metal products they buy.

A SOLID QUALITY PRODUCT . . .

Created by Allied Industries, of Wichita, Kansas, and built by Stearman Aviation, Inc., at Enid, Oklahoma, this bike was engineered from aircraft manufacturing experience. They naturally chose magnesium for the die-cast frame and steering fork.

. . . FROM EASY WORKING METAL

Along with its many other advantages, magnesium brings a ready adaptability to standard machining methods and accepted shop procedures. Its light weight means greater ease of handling, economy in manufacturing, and lower shipping costs.

—you'll buy *Magnesium Lightness too!*

DOWMETAL

DOW

As the nation's foremost producer of magnesium and magnesium alloys, Dow has built up a fund of technical information now proving invaluable to manufacturers. Consult Dow on applying magnesium to consumer and industrial products.

***MAGNESIUM DIVISION* • THE DOW CHEMICAL COMPANY • MIDLAND, MICHIGAN**

New York • Boston • Philadelphia • Washington • Cleveland • Detroit • Chicago • St. Louis • Houston • San Francisco • Los Angeles • Seattle

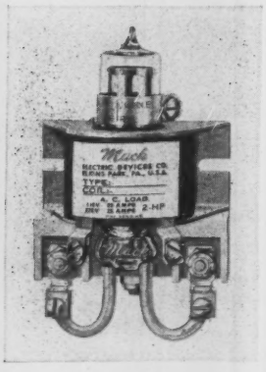
Dow Chemical of Canada, Limited, Toronto, Ontario

mounting surface to encourage air circulation if the heaters are mounted on the walls. The unit, identified as Type NOU Modified, has been developed to operate at oven temperatures up to 950 degrees. It measures 33½ inches long, 28 inches high and 3 inches deep. Physical dimensions and electrical rating may be altered to suit specific requirements. Units are furnished for single-phase operation only.

Humidity Indicator

MOISTURE-SENSITIVE INK, useful for the determination of moisture in rooms, containers, tanks etc., is announced by Eljay Enterprises, P. O. Box 891, Newark 1, N. J. The material, known as HygroInk, is humidity-sensitive, turning from blue-green to pink as humidity increases. Color change is distinct, definite and reversible, being a brilliant blue-green when dry and pink when moisture, dampness or humidity approaches the point where mold, mildew, corrosion, rust, warping take place. The ink may be painted, spray or printed onto surfaces. It dries in a few minutes at any temperature from 110 to 150 F. At room temperature it dries in an hour or so if the relative humidity is below 50 per cent.

Magnetic Relay



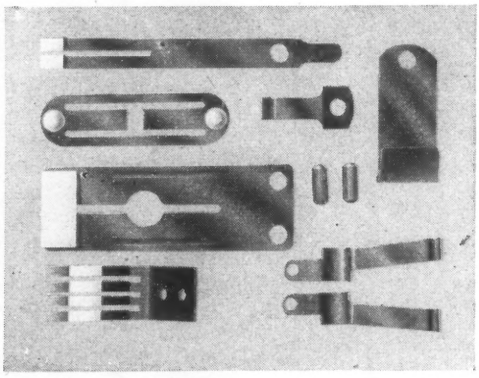
MERCURY-DISPLACEMENT type of magnetic relay is announced by Mack Electric Devices Co., 503 Township Line, Elkins Park, Penna. The unit, available in normally-open or normally-closed types, incorporates an hermetically-sealed glass container positioned in the magnetic field of the relay. A magnetic displacement device floating on the mercury within the sealed chamber is forced downward by the solenoid action of the coil, displacing mercury in such a manner as to close the circuit. The unit is dust and moisture proof, compact in size and will handle motor loads up to 2 hp. It is rated at 35 amp 110 v, 25 amp 220 v and measures 2 3/8 inches wide by 4 1/8 inches high.

Servo Motor

COMPACT LOW INERTIA MOTOR for remote control applications has been announced by the Transicoil Co., 114 Worth St., New York. The unit, designated as Model 2A servo-motor, operates on 60-cycle, two-phase current, and can be wound to operate on power from 10 to 80 volts or more. The servo, which will not operate on single phase current, has a practically constant impedance, and a stall torque of 1½ oz-in. which can be changed to specification. Stack length may be changed plus or minus 50 per cent to suit torque requirement, changing the overall length a maximum of ⅜-inch. Motor is furnished with separate leads for each phase, and a terminal board may be attached to rear of motor.

Contact Springs

BERYLLIUM COPPER electrical contact springs are now available from the Gibson Electric Co., 8360 Frankstown Ave., Pittsburgh 21. The new springs are recommended for use where exceptional spring properties com-

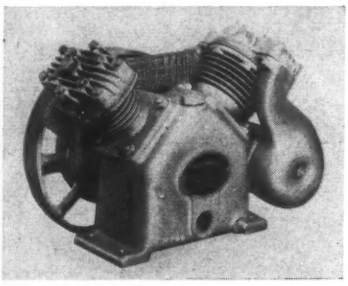


bined with high electrical conductivity are required. High physical properties—175,000 psi tensile, 18,500,000 psi modulus of elasticity—make beryllium copper the best spring material among nonferrous metals. Its electrical conductivity is 25 to 32 per cent IACS. Because of its hardness, beryllium copper is valuable for contact supports where good wear resistance is required.

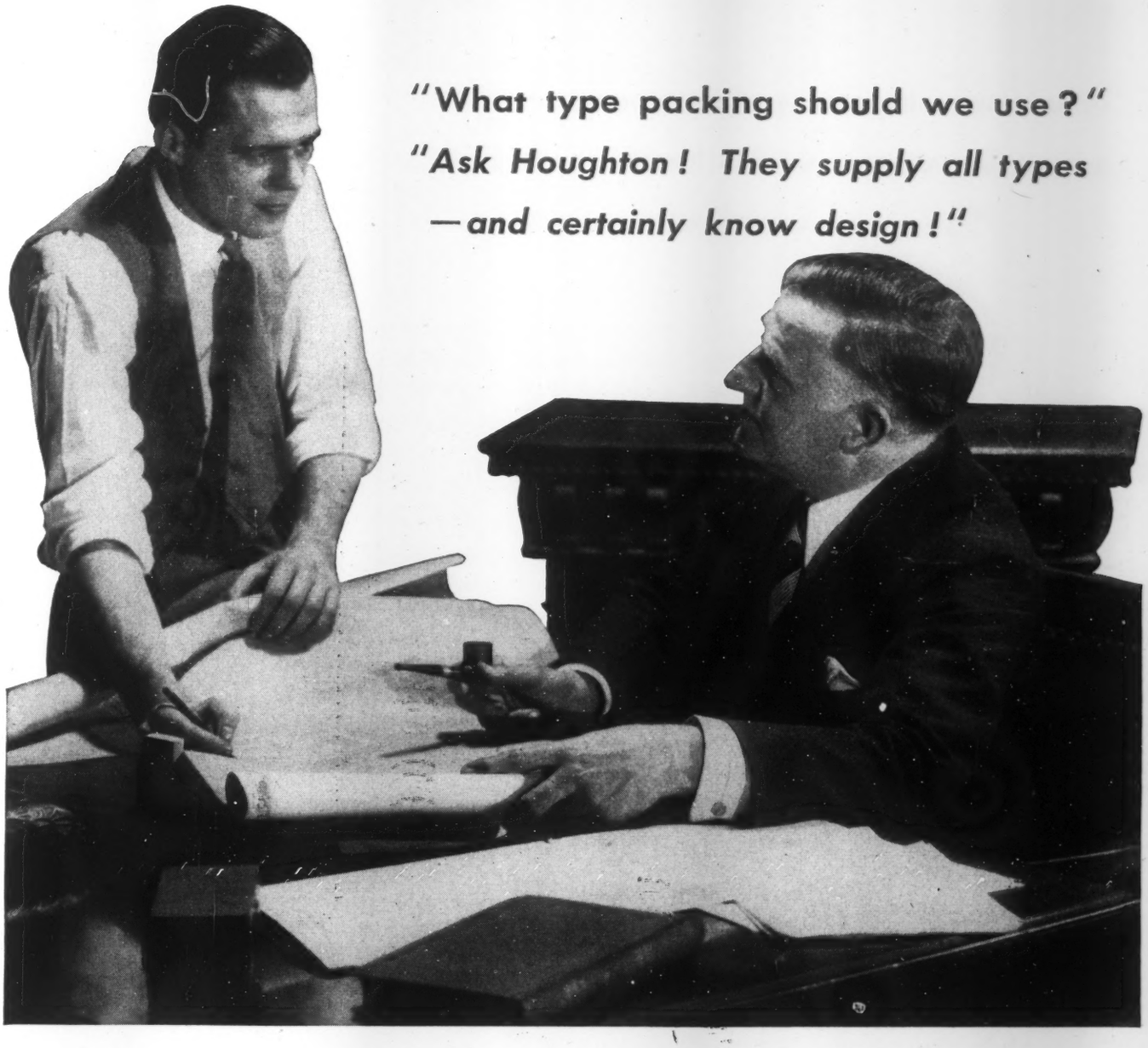
Solenoid Valve

THREE-WAY SOLENOID VALVE, announced on page 104 of this section in the October 1946 issue was illustrated by a photograph of a four-way, pneumatic type SR-4. The three-way valve resembles the four-way in most important particulars. Both units, manufactured by Numatics, Milford, Michigan, are electrically-controlled pneumatic valves.

Air Compressors



DESIGNED around established motor horsepower, a new line of air compressors has been announced by Worthington Pump & Machinery Corp., Harrison, N. J. Designated as "Air King" the line includes single-stage and two-stage sizes for pressures up to 250 psi for mating with standard motors of 1 to 15 hp, inclusive. Utilizing automatic starting, the unit has centri-



The oldsters know Houghton for past service on VIM Leather Packings for hydraulic and pneumatic service, dating back nearly forty years.

Now we also provide fabricated and synthetic rubber packings, including "O" rings, so that we offer *complete* packing service, with free design advice when needed. Therefore we can impartially recommend the best for your need. Given the facts or a blueprint, our hydraulic engineers will advise you without bias . . . will also recommend any design change which will provide a better seal.

So why not use this over-all coverage and knowledge? Send your packing problem to E. F. HOUGHTON & CO., 303 W. Lehigh Ave., Philadelphia 33, Pa.

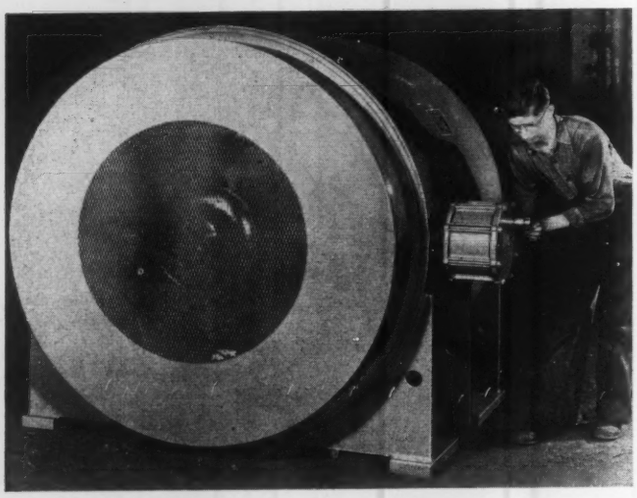
HOUGHTON'S

VIM LEATHER AND VIX-SYN PACKINGS

fugal clutch which permits driving motor to attain full speed before the compressor turns. This eliminates need for starting unloaders, check valves, etc. Direct drive eliminates transmission losses and drive adjustments. It provides simplicity. Available arrangements include self-contained power-driven models mounted on bases or tanks as well as unequipped compressors for either direct or V-belt connection to drivers.

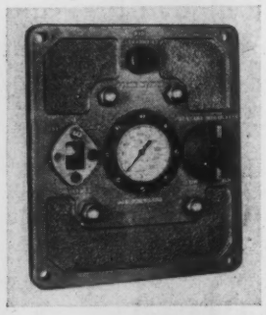
Weather-Proof Motors

COMPLETE LINE of outdoor weather-proof totally-enclosed motors in sizes ranging up to and above 2000 hp have been announced by the Allis-Chalmers Mfg. Co., Milwaukee, Wis. Ventilation heat-transfer system of the new unit has been completely redesigned. All air



passages are practically self cleaning and pockets in which liquid may be trapped have been eliminated. Air passage tubes can be easily cleaned with a brush or air hose. The new totally-enclosed all-fabricated steel motor is expected to find applications on draft fans, and in the chemical industry.

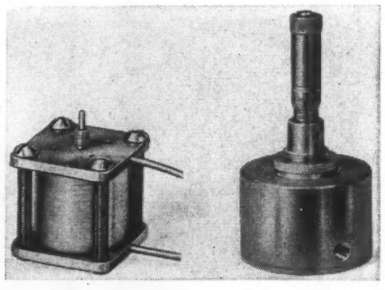
Pneumatic Control Unit



ASSEMBLY comprising air valve, pressure regulator, lubricator, air strainer and air gage, known as the Lehigh-Marton panel unit has been announced by the Marton Air Equipment Division, Lehigh Foundries, Inc., Easton, Pa. The complete assembly is designed in a compact form enabling machine tool and equipment builders to effect streamline design. The unit will accommodate ⅜-inch or ½-inch pipe size, and measures 8 1/16 inches wide and 9¼ inches high. Unit is so designed that it is possible to remove air strainer from front of panel. Air pressure is regulated by turning air pressure regulator knob for any desired pressure indicated by the gage.

Micrometer Valve

PRECISE and continuous control of the flow of either liquids or gases is said to be obtained by the use of the new Microl valve. The unit has 600 linear inches of capillary passage enclosed in a metal container 1½ inches square. Flow control is obtained by moving the adjust-



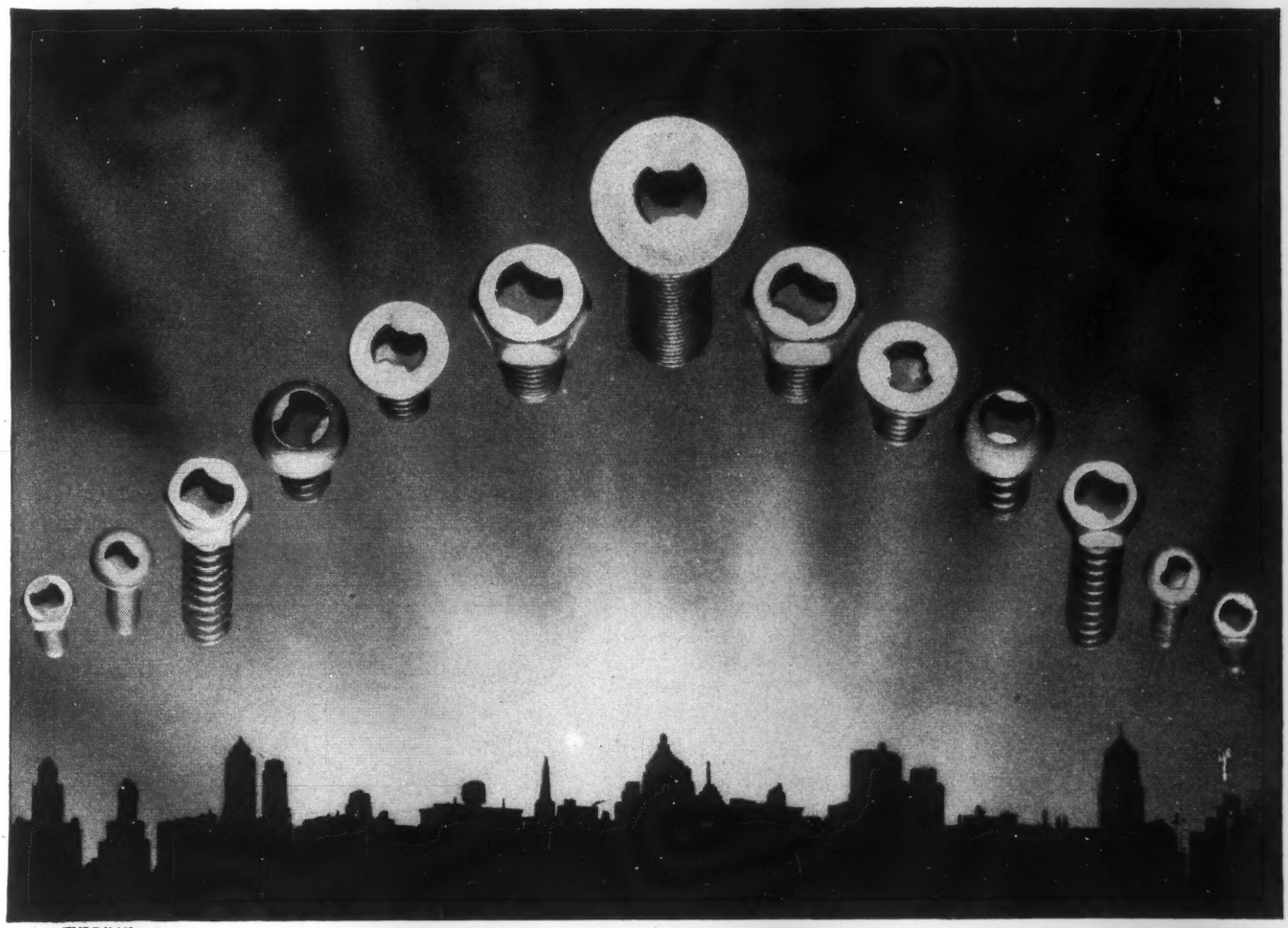
able plunger thereby continuously varying the length of the capillary passage from 4 to 600 inches. Valves are made of noncorrosive meterials and are said to withstand vibration of mechanical abuse. Flow of air or other fluids may be varied over the range of 0.2 to 60 cu in. per min with a pressure drop across the valve of 15 psi. Under the same conditions, the flow of water and other light liquids can be varied from 0.04 cc to 10 cc per min. Valve at left of illustration is standard unit, valve at right is laboratory test model to illustrate principle of valve. Manufacturer is Standard Instrument Co., 15 Elkins Street, South Boston, Mass.

Plastic Enamel

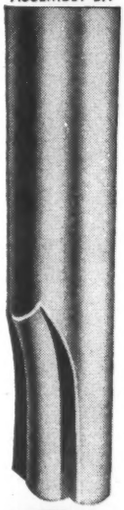
NEW ENAMEL well suited for severe service applications in high temperature has been announced by the Naugatuck Chemical Division of the United States Rubber Co., Naugatuck, Conn. The new synthetic resin enamel is resistant to high temperature and is applied by conventional methods and baked to an extremely durable finish. It is flexible and has high impact strength, superior hardness, high gloss and a minimum discoloration upon exposure to light or heat.

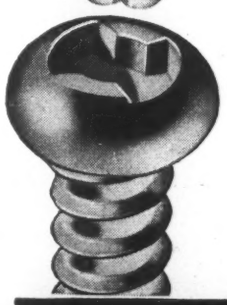
Rotameter

DESIGNED to meet a majority of industrial application requirements for rate-of-flow metering this Universal Rotameter manufactured by Schutte & Koerting Co., Philadelphia 22, is accurate, simply constructed, and convenient to use. The gas or liquid being metered passes through the Rotameter from bottom to top—causing the rotor to assume a position which is determined by rate-of-flow. The top of the rotor is read against clearly etched marks on the glass the calibration of which is uniform



TYPE "A" ASSEMBLY BIT





COMMON SCREWDRIVER

New Methods in industry impose new demands on assembly lines . . . for a new measure of economy through *faster, safer, easier,* and *better* production. Wherever power driving is used, the records show that CLUTCH HEAD Screws scale down the final costs with modern features and advantages which are *not matched by any other screw on the market today.*

VISIBILITY . . . The wide Clutch recess offers a clear, definite target, inviting confidence and unwavering action by the "greenest" operator. No "breaking-in" required.

SAFETY . . . The Center Pivot on the driver makes deep dead-center entry automatic. No canting, no slippage to injure manpower or damage materials.

EFFORTLESS DRIVING . . . The straight-sided driver squarely contacts the full area of the straight-walled Clutch to eliminate end pressure as a hazard and as a fatigue factor. With CLUTCH HEAD, there is no ride-out tendency as set up by "tapered" driving.

CLUTCH HEAD LOCK-ON . . . A slight reverse turn creates a friction-hold which unites screw and driver as a unit for easy one-handed reaching to hard-to-get-at spots. No slow-down fumbling. With field service Type "A" Bits, this feature functions automatically for easy withdrawal of screws, undamaged and saved for re-use.

NEW TOOL ECONOMY . . . .

Ruggedness of structure explains why this tool stands up through a longer continuous "spell" on the line. Repeated reconditioning to original efficiency requires only a 60-second application of the end surface to a grinding wheel.

CLUTCH HEAD · SCREWS ·

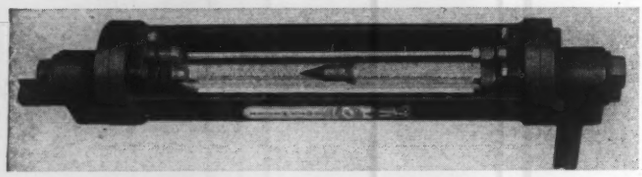
SCREWDRIVER CONTROL . . .

This is the only modern screw engineered for operation with ordinary type screw drivers or any flat blade of reasonably accurate width. Thickness of the blade is secondary because the roomy Clutch permits a wide tolerance.

UNITED SCREW AND BOLT CORPORATION

CLEVELAND 2 CHICAGO 8 NEW YORK 7

throughout the entire length of the scale. Pressure loss is practically negligible. The process fluid or gas does the indicating; there is no secondary fluid to leak or contaminate the system. A sturdy, cast frame takes all pipe stresses, supports and protects the metering tube. Glands are adjusted by accessible cap screws. The unit is easily



cleaned and readily installed in new or existing lines. Inlet and outlet pieces provide for either horizontal or vertical pipe connections and each can be connected to the machined frame ends in any of four different positions, 90 degrees apart.

New Reverse Switches

ANNOUNCED by The Euclid Electric & Mfg. Co., 1337 Chardon Rd., Euclid 17, Ohio, is a new line of reverse switches, identified as Type R-10. These reverse switches have been designed for starting and reversing small ac squirrel cage motors and dc motors that can be started without the use of accelerating resistors. Light in weight, these switches have a rating of 1.5 hp for single-phase 220 and 440-volt ac and dc motors and 3 hp for three-phase motors of the same voltage ratings. These switches combine the desirable characteristics of micro-processed be-

ryllium copper fingers with the long life of silver contacts. The fingers are fastened to the insulated steel shaft by means of easily removable bakelite snapclips. R-10 reverse switch operation is by pistol-grip handle, rope actuated lever or by thumb buttons with a pendant mounted handle. Suggested for applications on machine tool equipment and small hoists.

Industrial Adhesive

IDENTIFIED AS No. 4665 cement, a new industrial adhesive requiring no catalyst or special preparation has been announced by E. I. du Pont de Nemours & Co., Wilmington 98, Del. The new adhesive is described as being tough and flexible, suitable for bonding metal foils and metal sheets to wood, plastics, vulcanized synthetic and natural rubber and other substances having widely different coefficients of thermal expansion. Adhesive No. 4665 can be applied without thinning by brushing, roller coating, knife coating or dipping. It contains 27.5 per cent solids, and is insoluble in water.

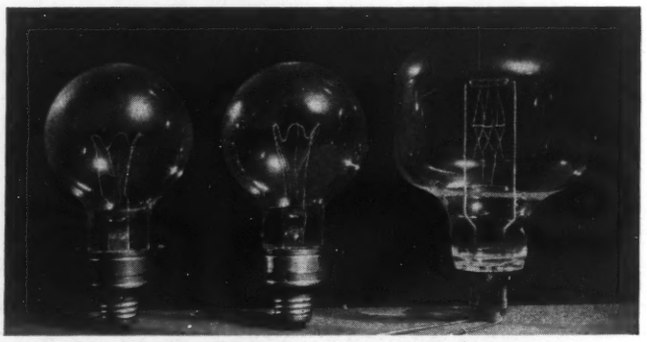
Forged Gasket

GASKETS for valves, valve bonnets and flanged connections, now being manufactured by the Steel Improvement & Forge Co., Addison & Metta Ave., Cleveland, are made of different metals to meet the requirements of varying service conditions. Forged in closed impression

dies, they are machined to exact dimensions for all services. They are available in two types (Type 0 is oval and Type K octagon) with a wide range of sizes including all standard API sizes.

Heat Lamps

THREE NEW infrared industrial lamps have recently been announced by the General Electric Co., Nela Park, Cleveland. Two smaller lamps are interchangeable, having a medium skirted base and are rated at 250 and 375 watts, respectively. The larger model, rated at 500 watts, is equipped with a medium bipost base and 6 inch flexible leads. It has been brought out to serve as a companion lamp to the present G. E. 1000 watt lamp. The lamps are designed to produce relatively high amounts of heat where needed in industrial applications.



Wichita City Libra

J-M Moulded Packing Cups

custom-made to fit right...seal tight

Tailored to meet any desired combination of service conditions, J-M Moulded Packing Cups offer designers a ready answer to packing problems.

Made of asbestos, duck or other fabrics, and impregnated with heat- or oil-resisting compounds selected for the particular conditions to be encountered, they retain their shape during long service . . . provide a positive seal with minimum friction under high pressure and temperature conditions. Available in a wide variety of shapes and sizes for use on all types of slow-moving pistons and rams operating against air, water, steam, oil, etc.

Tell us your requirements—we'll tailor the cup to fit your needs! Write today for the brochure, "J-M Packings for the Product Designer." Johns-Manville, Box 290, New York 16, N. Y.

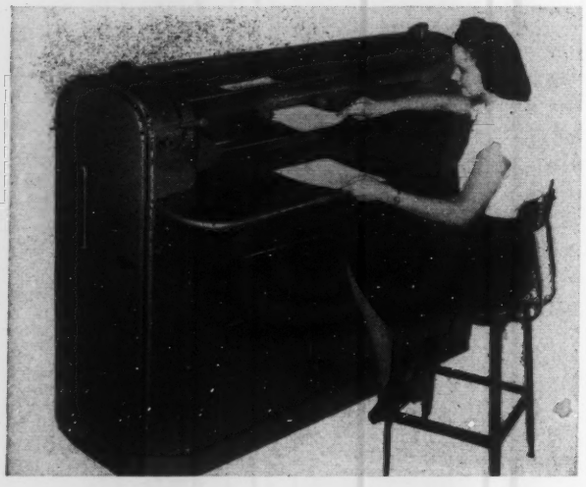
JOHNS-MANVILLE JM PRODUCTS

Johns-Manville
PACKINGS & GASKETS

engineering dept equipment

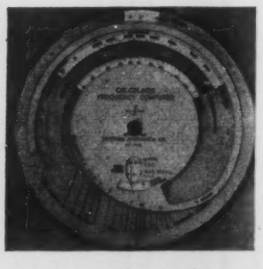
Drawing Reproducer

KNOWN AS the "Streamliner" a new printing machine has been announced by the Ozalid Division of General Aniline and Film Corp., Johnson City, N. Y. The new unit will reproduce anything drawn, typed, printed or photographed on translucent material as an easy to read positive copy. No intermediate steps are required. No chemical baths or inks are used and prints



are delivered completely dry, ready for immediate use after only two operations—exposure and dry development. The unit reproduces standard size engineering drawings, reports, file cards, etc. in 25 seconds at low cost and will provide reproductions in a variety of colors on a variety of materials. The machine accommodates materials up to 42 inches wide and of any length, prints at 10 ft per minute and develops at 5 ft per minute using ammonia vapor. Using a 1/3-hp motor the machine is 62-inches wide, 50⅛-inches high and 31-inches deep is of aluminum and steel construction.

Frequency Computer

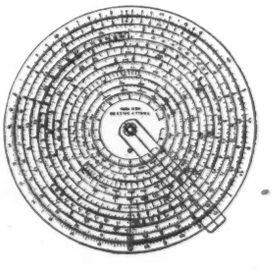


PROBLEMS involving frequency, induction and capacity are quickly solved with the Calculaide frequency computer devised by American Hydromath Co., 145 West 57th St., New York 19. The new instrument computes in one setting the natural frequency and wave length of a circuit comprising a known capacity and a known inductance or a known capacity and a coil with certain geometry. Inductance values can be determined for widely varying physical dimensions of coil and since all answers are given at a single setting the computer greatly simplifies resonant circuit calculations. The computer covers frequencies from 400 kilocycles to 150 megacycles and wave lengths from 2 to 600 meters. It handles condensers of capacity between 3 and 100 microfarads, performs calculations with coils of ¼ to 5½-inch diameter, ¼ to 10-inch length, 2 to 150 turns per inch of No. 10 to No. 35 wire. Measuring 6¼ inches in diameter and semiflexible the instrument may be conveniently carried in the pocket.

Low-Speed Tachometer

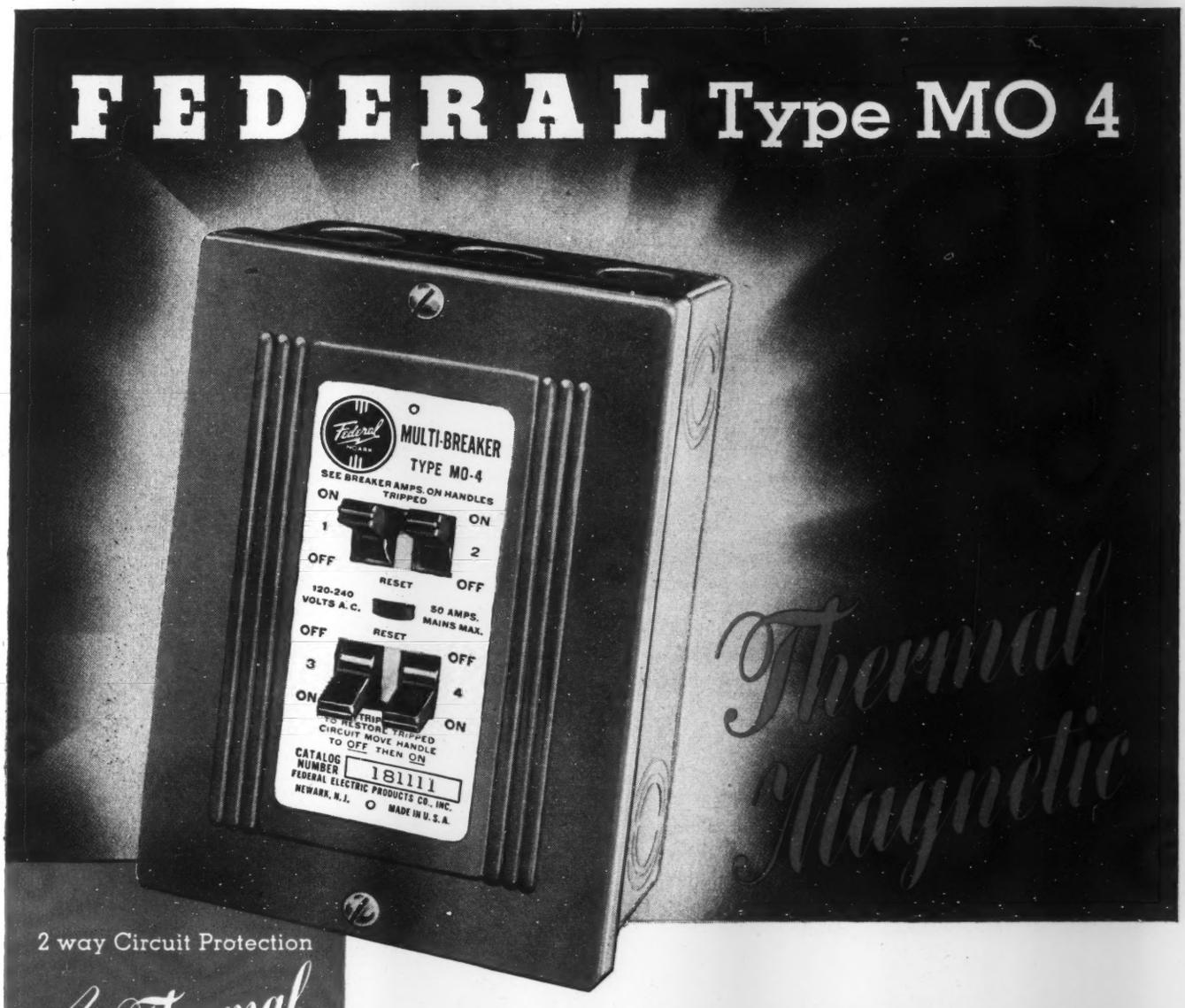
PARTICULARLY USEFUL for low speed measuring such as extrusion speeds in metal processing mills, is a new switchboard tachometer announced by the Metron Instrument Co., 432 Lincoln St., Denver. Known as the Metron series 40B tachometer the device consists of a tachometer head and an indicator or recorder mountable any distance from the head. Electronic in nature, the unit does not employ vacuum or generator tubes but utilizes a contact-making mechanism in series with a reactance and ammeter. Low torque is sufficient for operation, and long life with continuous use is obtained because of the few simple moving parts mounted in permanently-lubricated ball bearings. The accuracy is one per cent of full scale and is sustained even under adverse working environment. Both head and indicator are sturdily built. Multiple ranges and multiple head units are available. Operating power is obtained from 110 volts ac and calibration is unaffected by changes in line voltage.

Circular Slide Rule



LOG-LOG slide rule of a circular shape, based on a new principle has been announced by the Tavella Sales Co., 25 West Broadway, New York 7. The slide rule has two disks made of white Vinylite plastic. Disks have relative motion in much the same manner as the conven-

FEDERAL Type MO 4



2 way Circuit Protection

Thermal Magnetic

MULTI-BREAKER

Magnetic trip operates in a fiftieth of a second or faster, even on minor shorts. *Thermal* bi-metal element provides time-delayed tripping on moderate overloads. That's *THERMAL-MAGNETIC* Protection . . . built into Federal's new Type M04—the smallest, lowest-priced, most efficient Multi-breaker ever produced.

● 4-pole range ● For flush or surface mounting ● Only 5 1/16" x 7 3/16" x 2 7/8" ● Wire ratings 15, 20, 30 amp. ● Ideal wherever two lighting or appliance circuits and a small electric range circuit are needed . . . or where four lighting or appliance branch circuits are needed.

FEDERAL ELECTRIC PRODUCTS COMPANY—Executive Offices: 50 Paris Street, Newark 5, New Jersey. Plants: Hartford, Connecticut; Newark, New Jersey; St. Louis, Missouri.

Federal NOARK

Write for Bulletin No. 154

Federal NOARK INDUSTRIAL CONTROLS

FEDERAL ELECTRIC PRODUCTS COMPANY, MANUFACTURERS OF A COMPLETE LINE OF ELECTRICAL PRODUCTS INCLUDING: MOTOR CONTROLS, SAFETY SWITCHES, CIRCUIT BREAKERS, SERVICE EQUIPMENT, PANELBOARDS AND SWITCHBOARDS

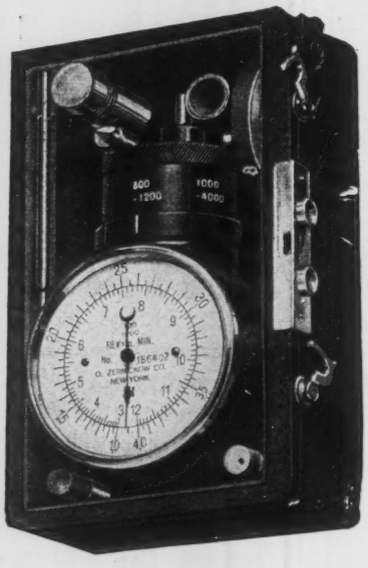
tional straight slide rule. The courser or indicator upon which the hairline is marked is of semiflexible clear plastic to safeguard against accidental breakage. The slide rule has A, B, C and D scales as well as log-log, K, sine and tangent scales.

Drafting Pencil

PENCIL consisting of a simple two part instrument—an aluminum body with a four jaw collet and a hardened knurled-steel grip has been announced by the Nord Products, East Orange, N. J. The pencil, known as the Nor-

drafter, measures 6 inches in length and is of aluminum construction. The four-jaw collet grip is said to give the user positive protection against the lead slipping or breaking.

Hand Tachometer



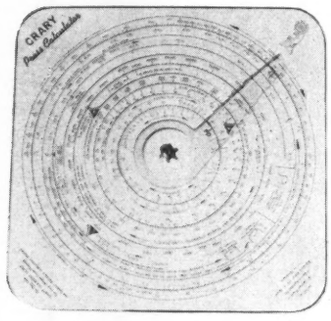
IMPROVED type of hand tachometer recently has been announced by the O. Zernickow Co., 15 Park Row, New York 7. The tachometer indicates rpm directly on a circular scale, with an accuracy within one-half of one per cent. It will measure rpm irrespective of direction of rotation and is unaffected by vibration, magnetism, etc. The unit may be used for measuring speeds from 30 to 4800 rpm or, with an adapting wheel, linear speeds from 15 to 2400 fpm. The above range is covered by three types of tachometers, catalog numbers 12, 24 and 48.

Electronic Micrometer

MICROMETERS for precise thickness measurement giving accurate readings to 0.00005-in. are announced by Carson Micrometer Corp., 28 Edison Place, Dept. 64, Newark 2, N. J. The instrument will measure thicknesses of compressible or noncompressible materials as well as those which are either conducting or nonconducting. Their precision is not affected by variations in temperature, line voltage, vibration or aging of electronic tubes. They feature extreme sensitivity to deviations as small as 0.000025 inch over a full one-inch range and will measure soft or compressible materials precisely. Units are portable and weigh twenty pounds.

Press Capacity Calculator

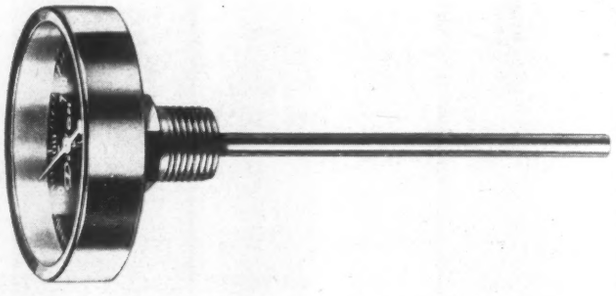
CIRCULAR RULE type of calculator for the determination of press capacity requirements of given forming work has been announced by the Calculator Co., P. O. Box 65, Teaneck, N. J. The calculator, which measures 9½ inches square, is made of heavy nonwarping Vinylite plastic with a clear sheet of Vinylite over printed surfaces for protection. For a given geometry of work, metal and

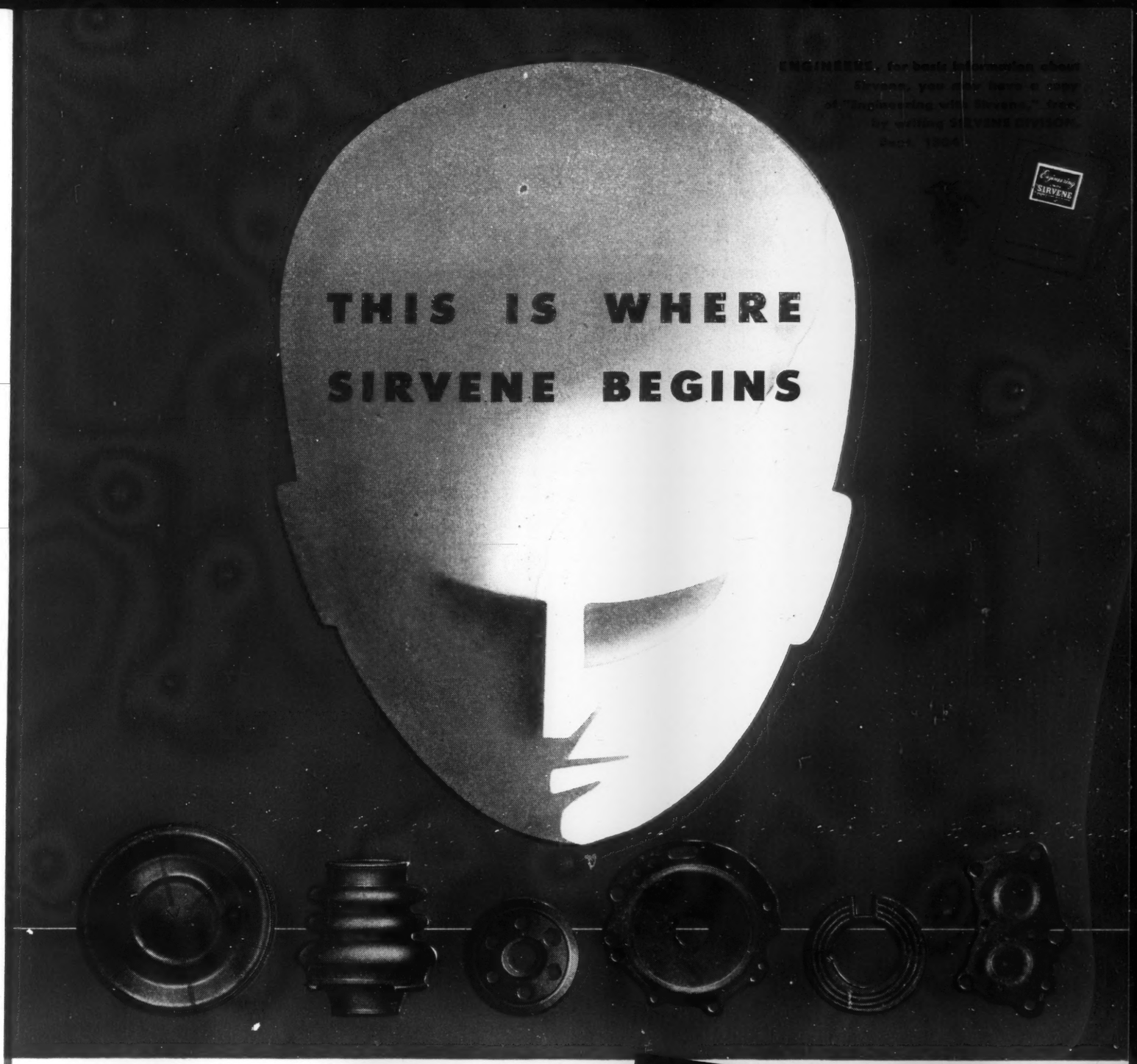


metal thickness, the calculator will determine the press capacity required crankshaft diameter and for drawing jobs the maximum press speed. Included with the calculator is a seventy-page booklet explaining how to operate the calculator and giving detailed information.

Thermometer

STAINLESS-STEEL housed bimetallic thermometer has recently been announced. The immersion type thermometer is made of 18-8 stainless steel and can be used for pressure applications. The dials, available in 3 and 5 inch diameters, are standard in fahrenheit graduations but may be obtained with centigrade scale if desired. Accuracy is unaffected by 50 per cent over-scale temperature on the 500 degree unit and 10 per cent on the 750-degree unit. Manufacturer is W. C. Dillon and Co., 5410 W. Harrison St., Chicago 44.





Sirvene begins in the mind of an engineer . . . it grows from the need for a special pliable part to complete his mechanism. It is specially compounded from oil resisting elastomers in Chicago Rawhide Laboratories to achieve required physical characteristics, then molded to precise design specifications. The finished Sirvene part meets *exactly* the engineer's demand for flexibility or hardness, resistance to temperature extremes, dryness, wear, age, oil, water, or other solvents. Sirvene parts deliver dependable performance under the most difficult operating conditions. For the solution to your pliable parts problem—consider Sirvene *first*.

Sirvene products include diaphragms, boots, gaskets, oil seals, washers, packings, and other special molded mechanical pliables.

SIRVENE

THE SCIENTIFIC COMPOUNDED ELASTOMER

A Product of the Synthetic Rubber Division

1305 Elston Avenue

Chicago 22, Illinois

ASSETS to a BOOKCASE

Rubber in Engineering

Prepared under the direction of the British Ministries of Supply and Aircraft Production, and of the Admiralty; published by the Chemical Publishing Co., New York; 304 pages, 5¾ by 8¾ inches, clothbound; available through MACHINE DESIGN, $5.50 *postpaid.*

Rubber, of all our engineering materials has, perhaps, the widest number of useful properties. However, the properties are subject to wide fluctuations when influenced by external physical and chemical phenomenon. Being thus effected by a number of variables, rubber has suffered by being discussed in few texts in the fear that the information was too unwieldy to print. In appreciation of this fact this book, based on research carried out by Imperial Chemical Industries, Ltd., was compiled under the direction of three basic British Ministries in an excellent endeavor to provide information on a subject of interest to a wide range of readers.

Because of the fundamental difference between rubber and other engineering materials, the viewpoints of both engineer and rubber technologist have been combined and compared throughout the book, hence, it is extremely broad in informative coverage. Mechanical properties of the material are covered as are physical and chemical properties. Discussed are: Tensile strength, shear moduli, hardness, etc., as well as the problems of aging, oil resistance, swelling and gaseous diffusion.

The last half of the book is devoted to the design of rubber parts. The design of such parts as springs, vibration mounts and shear mountings are discussed in detail as well as units involving rubber to metal bonds.

□ □ □

Magnesium

By Pidgeon, Mathes, Woldman, Winkler and Loose, published by the American Society for Metals, Cleveland; 385 pages, 6¼ by 9¼ inches, clothbound; available through MACHINE DESIGN, $3.50 *postpaid*

Magnesium, by reason of its low weight, is finding many applications since high production brought on by the war lowered its cost. There are, however, numerous reasons for its usefulness, other than lightness which made it valuable for aircraft use. If the strength-weight ratio, for example, is considered, magnesium is stronger than mild steel. The modulus of elasticity is quite low, making the metal desirable for vibrating parts inasmuch as stresses will be lower for given values of strain. Magnesium alloys thus have valuable fatigue and high damping properties and are useful for the manufacture of gear housings because they absorb noise.

The authors have prepared a book of unquestioned value to the machine designer. Restricting themselves to the subjects design and properties of magnesium, they answer in the text most of the questions that will come to the designers' mind. Discussed are such topics as structural design, castings, corrosion and protection, and methods of fabrication. Information is, in general, quantitative, and the book is replete with tables, curves and illustrations.

□ □ □

Hoyer-Kreuter Technological Dictionary

Published by the Frederick Ungar Publishing Co., New York; in three volumes; available through MACHINE DESIGN, $50.00 *per set postpaid.*

Of value to those engineers having frequent occasion to refer to foreign publications, this work gives in three volumes translations covering French and German, the two languages other than English most widely used in technical writing. Each volume translates from a single language to the other two; Volume I giving the English and French versions of German expressions, Volume II the French and German for English terms, and Volume III translating French to German and English.

The dictionary, said to be the most comprehensive of its kind ever published, covers terms used in all branches of basic engineering as well as specialized industries such as agriculture, textiles, foodstuffs, shipbuilding, and mining. Also covered are patents, laws and customs. The book seems well balanced in content and detailed in explanation. Not only are terms translated, but related phrases are as well. For example, under the expression "accumulator" are given the idioms for "to overcharge the accumulator"—"den sammler uberladen" and "surcharger l'accummulateur."

Valuable book for the engineer concerned with the design or the application of diesel engines has been published under the title of "Standard Practices for Stationary Diesel Engines." The 157-page book, an up-to-date revision of the 1935 edition, gives in general terms the design standards found to be most desirable after many years of experience.

Covered are such subjects as general construction, cooling systems, lubrication systems, electrical equipment lubricant specification and the test code.

The book is carefully written in accessible headed-paragraph form so as to provide a ready reference. It is clothbound, measures 6¼ by 9 inches, and is available at $2.50 from the Diesel Engine Manufacturers Association, one North La Salle St., Chicago 2.

I look for all 8 to get t.f.e.

True Fastener Economy

It is the many costs of using a fastener that count . . . not just the initial price. *True Fastener Economy* is the lowest *total* cost for fastener selection, purchase, assembly and performance.

YOU GET t.f.e. WHEN YOU . . .

1. Reduce assembly time to a minimum by savings through use of accurate and uniform fasteners

2. Make your men happier by giving them fasteners that make their work easier

3. Reduce need for thorough plant inspection, due to confidence in supplier's quality control

4. Reduce the number and size of fasteners by proper design

5. Purchase maximum holding power per dollar of initial cost, by specifying correct type and size of fasteners

6. Simplify inventories by standardizing on fewer types and sizes of fasteners

7. Save purchasing time by buying larger quantities from one supplier's complete line

8. Contribute to sales value of final product by using fasteners with a reputation for dependability and finish

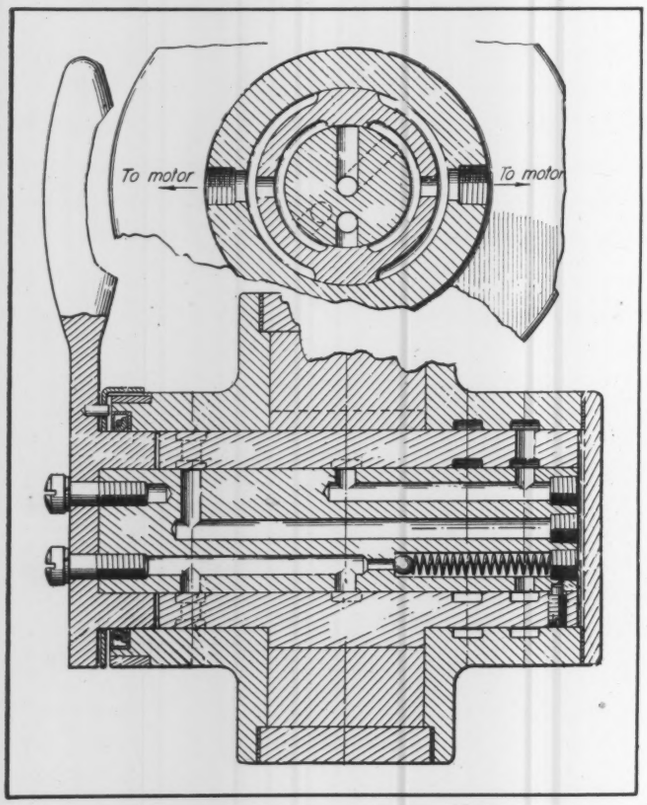
RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

102 years making strong
the things that make America strong

Plants at Port Chester, N. Y., Coraopolis, Pa., Rock Falls, Ill., Los Angeles, Calif. Additional sales offices at Philadelphia, Detroit, Chicago, Chattanooga, Portland, Seattle. Distributors from coast to coast. By ordering through your distributor, you can get prompt service for your normal needs from his stocks. *Also*—the industry's most complete, easiest-to-use catalog.

Noteworthy Patents

PRECISION SERVO CONTROL of a hydraulic hoist or motor is achieved by means of an unusual valve design assigned to Hydraulic Control Engineering Co., by W. T. Stephens under patent 2,406,173. A lost-motion action in the valve plunger provides a positive means of sealing the



fluid accurately and automatically and at the same time prevents overtravel or flutter. Synchronization of the elements is simple, retiming being achieved by a number of reversals from full open one way to full open the other.

EFFECTIVE SEALING between air and hydraulic fluid without the volume limiting restrictions of a diaphragm is provided by an accumulator design covered in patent 2,406,197 by Neils A. Christensen. Utilizing a centrally-guided piston with an O-ring seal, the design eliminates metal-to-metal contact between the elements. Design of the O-ring groove creates an oscillating movement of the ring thereby effecting a kneading action which keeps the material alive and pliable while at the same time maintaining a fluid-tight seal.

ADJUSTMENT OF TAPERED ROLLER BEARINGS is provided, without allowing any possibility for the inner race of the adjustable bearing to rotate, by means of a novel mounting design covered in patent 2,407,532. Assigned to Timken Roller Bearing Co. by Ernest G. Boden, the invention consists principally in interposing between the corresponding bearing members, one of which is rigidly mounted and the other loosely mounted, a resilient spacer member which yields to endwise movement of the loose member but prevents rotation relative to the rigid member.

ONE-WAY ROTATION RATCHET mechanism with provision for positive locking in any position is covered in patent 2,409,009 assigned to General Electric Co. by Hans A. Bakke. The pawl lever utilized is a permanent magnet in the shape of an arc pivoted near its center. The pawl end of the lever, being polarized north, is attracted to the teeth of the ratchet, which are polarized south. The tail of the pawl lever, being polarized south, naturally is repelled and assists the pawl action. To assure positive locking should the rotation not move a full tooth pitch length, a magnetic one-way clutch is utilized, magnetic force again providing a wedging and locking action.

AUTOMATIC PATTERN FOLLOWER control covered in patent 2,410,295 provides a simple, reliable and accurate system for automatic machines such as millers, lathes, etc. Cutter and workpiece are driven at a constant speed for all angles of relative movement so that tool marks are evenly spaced, and a stepless contour is produced regardless of the shape being generated. Control of the driving mechanism used is obtained from a control voltage produced by a magnetostrictive tracer whose magnetic permeability is varied in response to the application of force from its tracing finger. The patent is assigned to the General Electric Co. by Hans P. Kuchni and Norman G. Branson.

BETTER SURE THAN SORRY

According to olden legend Icarus flew too near the sun, only to spin in when his wings failed to stand the stress at high temperature. Here was an early case of serious trouble due to misplaced confidence in materials.

There are many applications for steel nowadays where creep strength (the ability of steel to keep working when the heat is on) makes a tremendous difference. Molybdenum steels, being noted for their creep strength, are economical preventives of high temperature trouble.

Icarus had no accurate data on materials to guide him. A wealth of tested, practical facts about Molybdenum steels for elevated temperature service is available on request for today's engineers and designers.

MOLYBDIC OXIDE—BRIQUETTED OR CANNED • FERROMOLYBDENUM • "CALCIUM MOLYBDATE"
CLIMAX FURNISHES AUTHORITATIVE ENGINEERING DATA ON MOLYBDENUM APPLICATIONS.

Climax Molybdenum Company
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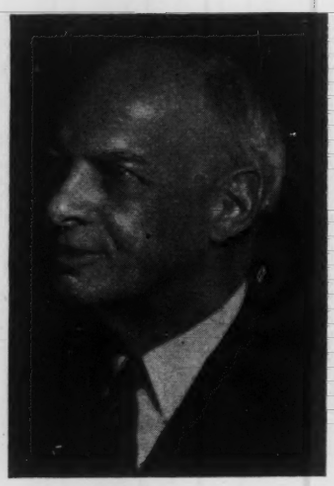
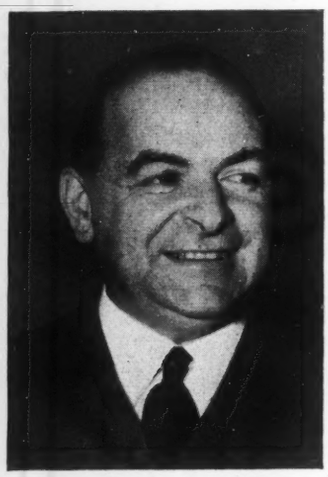
MOLY

MEN...of...machines



Howard Coonley



Frederick R. Lack

Edward N. Cole

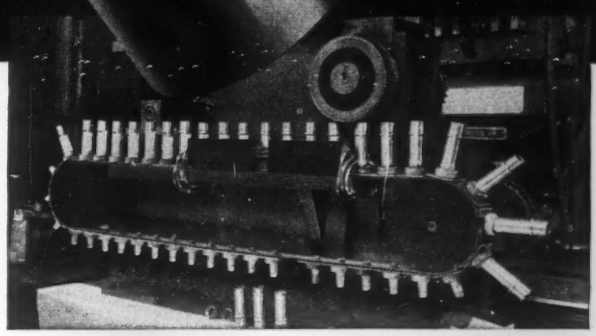
HOWARD COONLEY, chairman of the Executive Committee of the American Standards Association, has been elected president of the new International Organization, the formation of which has been completed recently by delegates from twenty-five nations meeting in London. During both wars Mr. Coonley has played a major role in standardization activities. In the First World War he was an associate of Charles Schwab and served as vice president of the Emergency Fleet Corp., devoting his time to standardization in the ship production program. During World War II he directed conservation, standardization, simplification and specification work of the War Production Board. As special deputy to Donald M. Nelson in 1944, he was made personal representative and adviser to the Chinese Government in setting up the Chinese War Production Board. Mr. Coonley retired from the chairmanship of the board of the Walworth Co. at the end of 1945. He was then persuaded by those who were anxious to see private enterprise regain control of standards to devote his time to reorganizing the American Standards Association, of which he is a past president.

FREDERICK R. LACK, recently elected president of the American Standards Association, is vice president and a director of the Western Electric Co. in charge of its radio division. Mr. Lack became vice president and a director of the Western Electric Co. in 1942 after a career with the Bell Telephone System which began as an assembler in 1911. For a time during the late war he was a director of the Army and Navy Electronics Production Agency, and during the first war served in France with the Signal Corps. In addition to his presidency of American Standards Association, Mr. Lack is a director of the Institute of Radio Engineers, the Radio Manufacturers' Association and the Smith-Winchester Mfg. Co. He is also president of the Harvard Engineering Society, and is a member of the American Institute of Electrical Engineers and the American Physical Society.

EDWARD N. COLE, new chief engineer at the Cadillac Motor Car Division, reflects the value of training men directly for the automotive industry in his swift rise to the top engineering position with the company. Mr. Cole, while studying law in 1930, picked up a bulletin on the Cadillac training program and became sufficiently interested to enroll. Upon completion of the course, he was offered a job as laboratory assistant. Later he was promoted to technician and designer, and specialized in the development of the engine used in all Cadillacs since 1936. As engineer in 1938 he was assigned to technical problems and continued in this capacity until 1943 when he was named chief design engineer. During this time Mr.

WHY 22?

BRAZE 220 PER HOUR WITH TOCCO



PRATT & WHITNEY Aircraft Division of United Aircraft Corporation reports these economies in the TOCCO-brazing of steel tips to bronze bodies of valve guide assemblies:

FORMER OUTPUT: 22 per hour per operator by manual brazing.

TOCCO OUTPUT: 220 per hour per operator by TOCCO Induction Heating . . . 10 times as fast as former method . . . for *lower costs*.

PROCEDURE: The valve guide parts, fluxed and assembled with solder ring, are placed on pegs on a moving belt. This handling fixture passes the parts through an inductor coil where they are TOCCO-heated to 1200° F. and silver soldered . . . an automatic and continuous operation.

TOCCO Engineers are at your service to help improve *your* production. No obligation.

THE OHIO CRANKSHAFT COMPANY

FREE BULLETIN

TOCCO

Mail Coupon Today

THE OHIO CRANKSHAFT CO.
Dept. B, Cleveland 1, Ohio

Send free copy of
"INDUCTION HEATING".

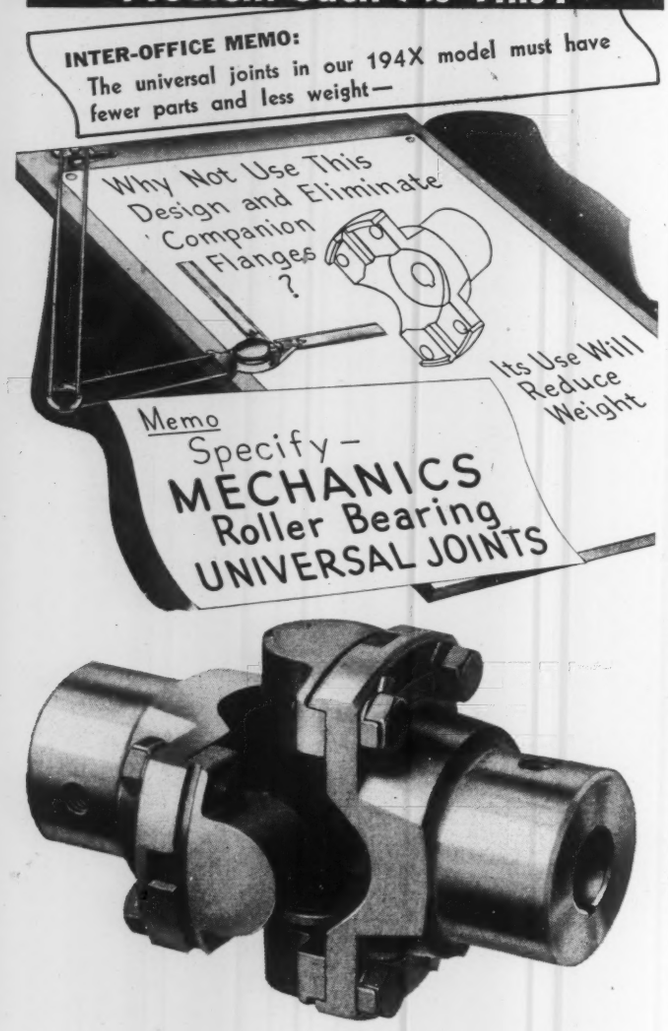
Name.....

Company.....

Address.....

City.....Zone...State...

What Would You Do About A Problem Such As This?



MECHANICS Roller Bearing UNIVERSAL JOINTS eliminate the need for companion flanges — without sacrificing ease of assembly.

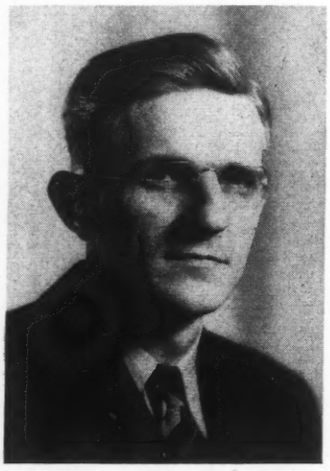
By taking full advantage of the MECHANICS design, a substantial weight reduction can be accomplished — at a point where fewer parts, minimum weight and faster assembly represent competative advantages.

Let our engineers show you how this and other MECHANICS Roller Bearing UNIVERSAL JOINTS features will benefit your new or improved models.

MECHANICS UNIVERSAL JOINT DIVISION
Borg-Warner • 2026 Harrison Ave., Rockford, Ill.

Cole was sent to Washington to check into the installation of Cadillac engines in light tanks. He handled the development and testing that led to the acceptance of the engine as standard for all United States light tanks. During the war, Mr. Cole worked on the engineering of twenty experimental vehicles seven of which were put into production for the army. In 1944 when he was promoted to assistant chief engineer, he was faced with the dual chores of starting to shape up the engineering program for postwar cars as well as continuing to work on war production. His rise to his new post as chief engineer comes just fourteen years after his graduation from the General Motors Institute.

♦



HAROLD W. BALL, prior to being elected chief engineer of the Foster Machine Co., served as research engineer for the company. In this capacity he was in charge of the development of a new winding machine for the synthetic yarn industry. Before becoming associated with the Foster company, he spent about five years with the Du Pont organization as a member of technical supervision in their nylon plant at Seaford, Del. Prior to that, Mr. Cole obtained considerable machine design experience in his connections with Dunlop Tire & Rubber Co., Ross Heater & Mfg. Co., National Aniline & Chemical Co., and the Buffalo Forge Co. He is a member of the American Society for Metals and has underway an application for membership in the American Society of Mechanical Engineers.

♦

THOMAS G. VALENTY, recently discharged from the service, rejoined D. W. Onan & Sons, Minneapolis, as a mechanical engineer in the engine design section of the company.

♦

ALBERT E. WILSON recently has been named vice president in charge of engineering, Keal Industries, Cleveland.

♦

CHARLES A. HUBERT, associated with International Harvester Co. since 1937, will succeed LEONARD B. SPERRY, retired, as manager of engineering of the company's farm tractor division in Chicago. Mr. Sperry is retiring after thirty-eight years of service.

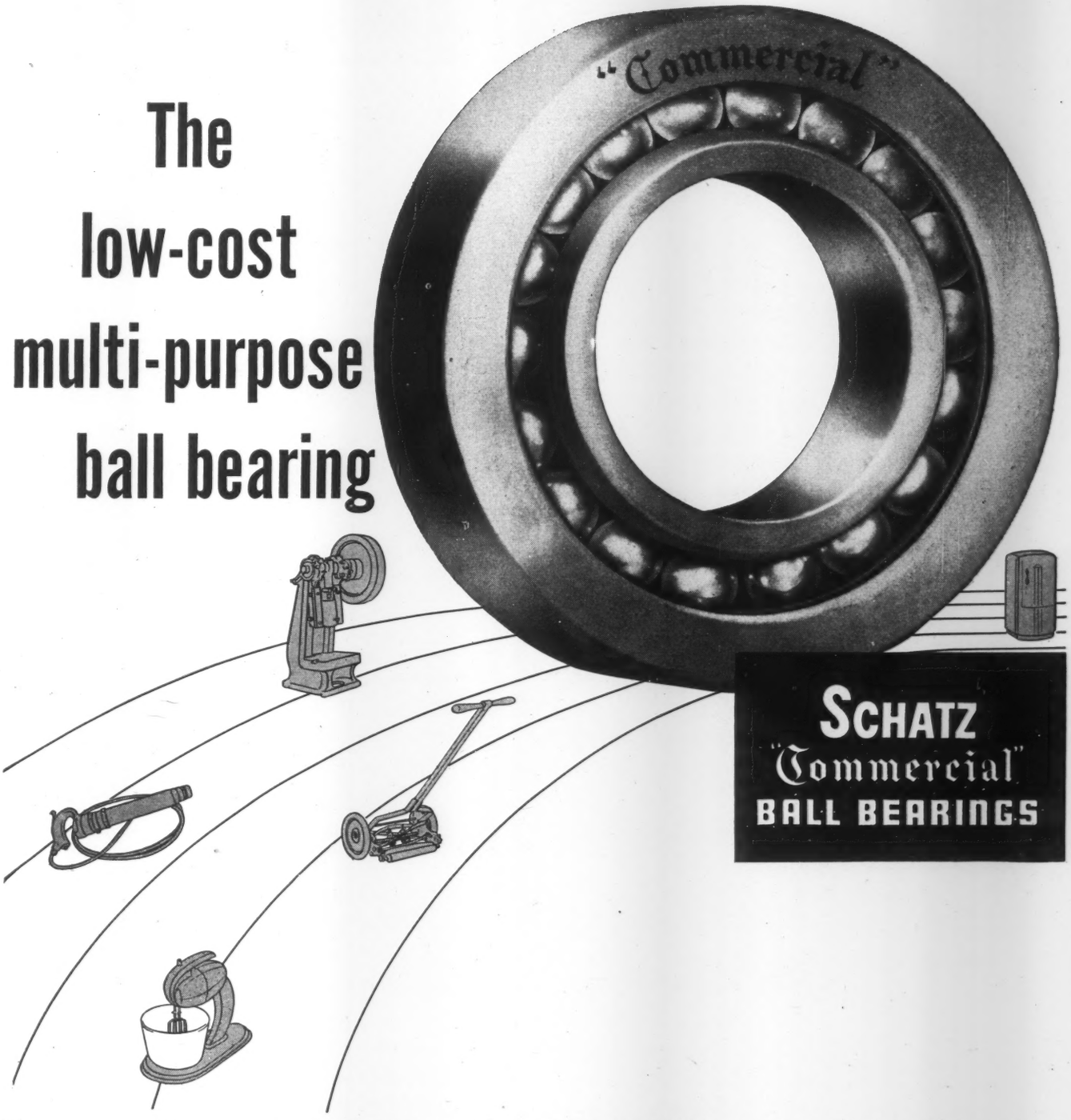
♦

MILES E. JOHNSON, who had been chief product engineer of Continental Aviation & Engineering Corp., has been elected first vice president of the newly organized Melrotor Industries Inc., Muskegon, Mich.

♦

FRANK G. WOOLARD, well known design and production engineer and industrial executive, has been re-elected president of the Institution of Automobile Engineers (Great Britain) on the eve of the amalgamation of that organization with the Institution of Mechanical Engineers.

The low-cost multi-purpose ball bearing



You write "rugged" into your blueprints—at low-cost—when you make Schatz "Commercial" Ball Bearings part of your design. For, unlike other moderate-priced bearings, "Commercials" combine *through-hardened* chrome alloy balls with high-grade, low-carbon, cold-rolled steel rings.

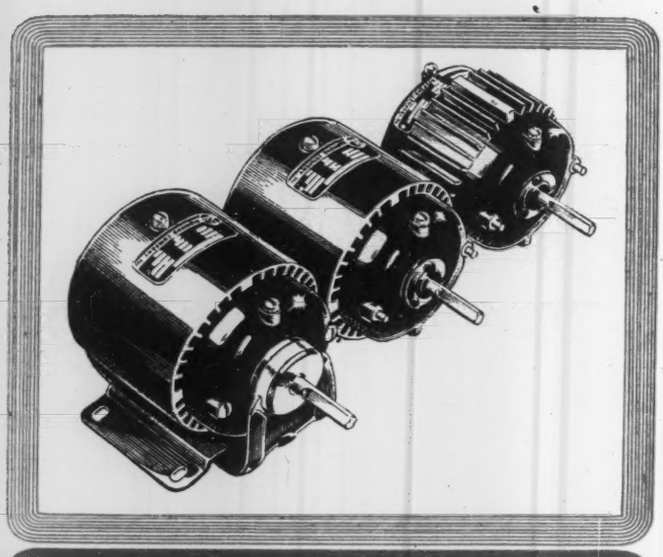
Long bearing life is equal to the sum of these parts... and extra-utility, too. So it's not unusual to find "Commercials" rolling along in all kinds of service, delivering efficient, friction-free operation in stamping presses and lawn mowers, or in riveting machines and refrigerators.

Compare their on-the-job performance with other low-cost ball bearings. And consider, too, the plus value of Schatz engineering counsel while your application is in the design stage. A fifty year fund of ball bearing "know-how" is at your disposal.

Schatz "Commercials" are manufactured in all standard types and sizes to cover the wide range of ball-bearing applications where moderate cost is a vital factor alongside of maximum efficiency. The answer to your anti-friction problem is among them.

Remember, Schatz makes only ball bearings, and "Commercials" are manufactured only by Schatz.

THE SCHATZ MANUFACTURING COMPANY
POUGHKEEPSIE, NEW YORK
REPRESENTATIVES LOCATED AT
Detroit: 2640 Book Tower—26 • Cleveland: 402 Swetland Building—15
Chicago: 8 S. Michigan Ave.—3 • Los Angeles: 5410 Wilshire Blvd.—36



How much should be expected of a small motor?

Well, here's what a Redmond Micromotor does.

In a year's time a Redmond AC Micromotor operating on continuous duty at 1500 RPM delivers over seven hundred million revolutions.

With only infrequent additions of small quantities of lubricant a Micromotor turns out these millions of revolutions year after year, retaining its original fine performance.

You can expect a great deal from a Redmond Micromotor, for it is engineered and built by specialists whose efforts are concentrated on small fraction horsepower motors and their applications.

Redmond MICROMOTORS

REDMOND COMPANY, INC., OWOSSO, MICHIGAN, U.S.A.

AC Micromotors in sizes up to 1/25th hp., DC Micromotors up to 1/70th hp., combination and fractional

REDMOND

BUSINESS AND SALES BRIEFS

FORMERLY in the general sales office in Pittsburgh, Gilbert E. Collyer has been appointed district manager of the Detroit office of H. K. Porter Co. Inc. His headquarters are at the Porter office at 642 Book Bldg., Grand River and Washington Blvd., Detroit 26.

♦

Purchase of the Morck Brush Mfg. Co. of San Francisco has been announced by Pittsburgh Plate Glass Co. The new unit will continue operation as the Morck Brush Division of the company. Frank F. Tippett, previously associated with the Baltimore brush plant, will serve as manager of the newly acquired factory.

♦

National Tube Co., a U. S. Steel subsidiary, has appointed Henry J. Wallace as general sales manager to succeed W. F. McConnor who recently was elected vice president in charge of sales. Prior to his appointment Mr. Wallace was sales manager of the eastern area, with offices in New York.

♦

With headquarters at the home office in Grand Rapids, Mich., Robert L. Shoemaker has joined the sales promotion staff of Lear Inc. and will be active in promotion work on the Lear Luxor, a complete aircraft radio and automatic flight control for the private airplane.

♦

A new warehouse has been opened at 1270 McCook Ave., Dayton, O., by the Allegheny Ludlum Steel Corp. of Pittsburgh. Under the supervision of R. J. Swan, district manager, the new warehouse will serve southwest Ohio and the state of Kentucky.

♦

Previously service engineer at the Milwaukee office, Elmer Anderson has been named assistant service manager of the Canton, O., office of The Timken Roller Bearing Co. Mr. Anderson has been associated with the company since 1929.

♦

Completion of a modern two-story office building adjoining its Pittsburgh steel-service plant has been announced by Joseph T. Ryerson & Son Inc., Chicago. Temporary office space had been occupied on Main St. in the town of Carnegie. The new building is located at Arch St. and Bell Ave., Carnegie, and provides for maximum speed and efficiency in handling orders.

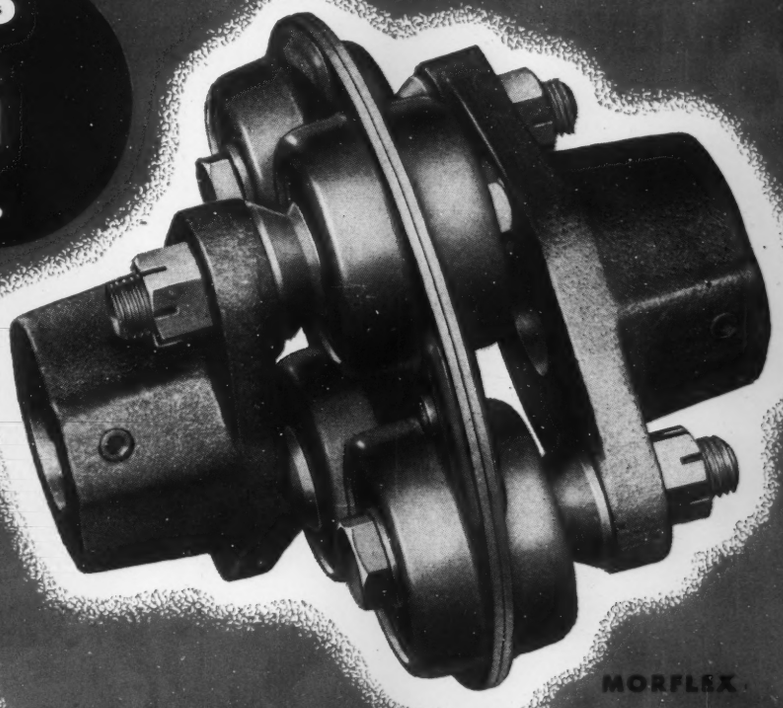
♦

Oscar G. Knapp has succeeded the late Edwin S. Todd as president and treasurer of Clark Bros. Bolt Co. of Milldale, Conn., manufacturer of bolts, nuts, screws and rivets. Dudley H. Smith has been appointed secretary and general sales manager.

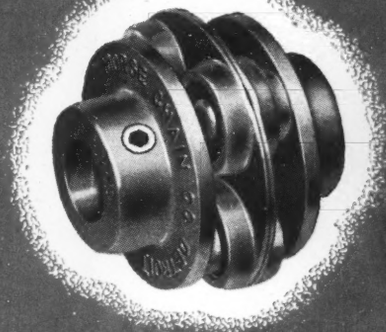
♦

Recent personnel changes have been announced by American Foundry Equipment Co. of Mishawaka, Ind. Ardee H. Freeman, previously district sales engineer for the Milwaukee territory, has returned to the Mishawaka office as special project engineer. Succeeding him at Milwaukee is James H. Thomson who formerly handled sales engineering for Wheela-

COUPLINGS FOR BIG JOBS . . .

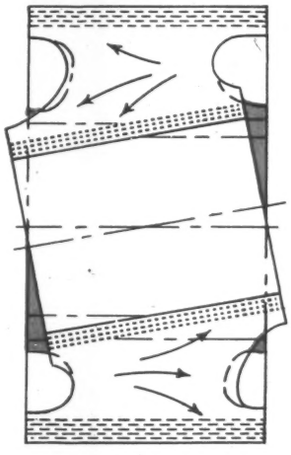


MORFLEX



MORFLEX JUNIOR

and LITTLE JOBS



Specially-shaped Neoprene biscuits, pre-loaded in assembly, distribute uniform stress throughout their volume under all conditions. Arrows indicate deflection as biscuit compensates for angular misalignment of connected shaft.

MORFLEX COUPLINGS

Cushion Shock, Isolate Vibration
Prolong Machine Life

Morflex Couplings, available in 12 sizes of 3 to 725 foot pounds torque capacity, protect big machine installations and fractional horsepower applications alike.

The exclusively Morse-designed Neoprene biscuit assembly permits maximum smooth power delivery, isolates uneven impulses for longer machine life.

Morflex Couplings require no lubrication. They're clean—do not soil products, and are unaffected by oil, dirt or weather.

MORSE CHAIN COMPANY • Detroit 8, Michigan • Ithaca, N. Y.

MORSE

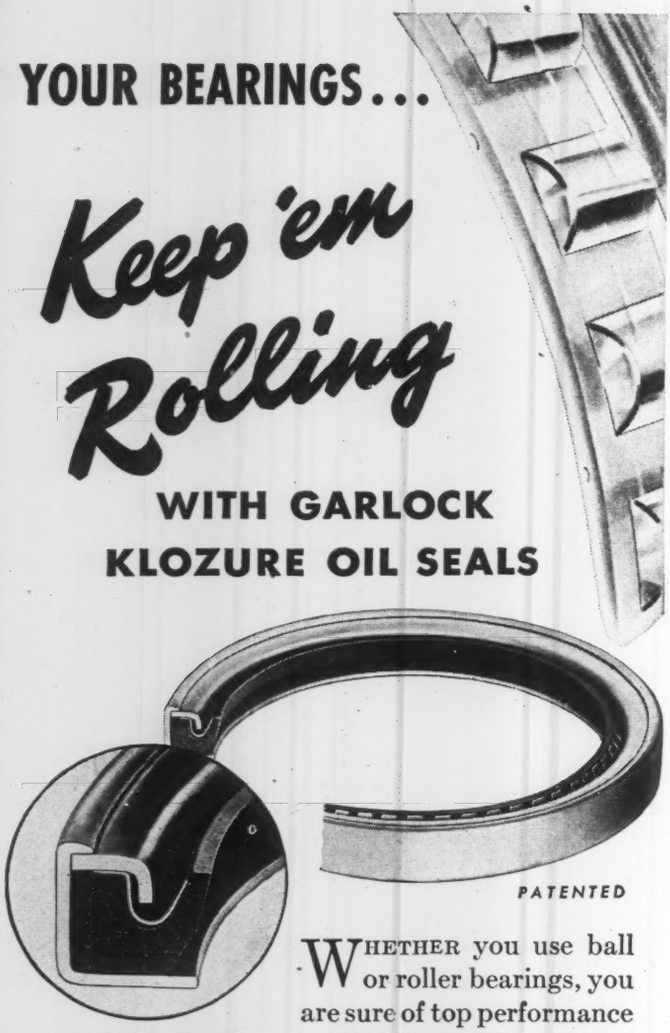
MECHANICAL POWER TRANSMISSION PRODUCTS

A PRODUCT OF B-W BORG-WARNER

YOUR BEARINGS...

Keep 'em Rolling

WITH GARLOCK KLOZURE OIL SEALS



PATENTED

WHETHER you use ball or roller bearings, you are sure of top performance with Garlock KLOZURE Oil Seals. The special compound used in the KLOZURE sealing ring remains firm and resilient. It keeps *out* dust, dirt and water; *seals in* oil and grease—assuring protection and proper lubrication to keep bearings rolling efficiently. Complete range of sizes including Metric O.D. to fit standard bores.

THE GARLOCK PACKING COMPANY
PALMYRA, N. Y.

In Canada: The Garlock Packing Company of Canada Ltd., Montreal, Que.

GARLOCK Klozure OIL SEAL

brator special cabinets and Airblast equipment in the Mishawaka office. E. P. Clarke has been assigned to the Houston, Tex., sales office where he succeeds Joseph F. Underway, who has been transferred to St. Louis.

♦

A two-story adjacent brick building at 10 Hygeia St., Worcester, Mass., has been acquired by Worcester Moulded Plastics Co. It provides an additional forty per cent square feet of space.

♦

Formerly executive vice president, George P. Torrence has been named president of the Link-Belt Co., Chicago. He succeeds William C. Carter who retired recently. Mr. Carter still maintains his position as director of the company and chairman of the executive committee of the board, and will continue to give the company the benefit of his long experience by serving as a consultant.

♦

Plans for immediate construction of a new factory and office building have been announced by Jas. P. Marsh Corp. of Chicago, manufacturer of industrial instruments and heating specialties. The new building will be erected on a five-acre tract of land located at Howard St. and St. Louis Ave. in Skokie, Ill., a suburb of Chicago.

♦

John Neuman, president of Nu Engineering Inc. of Ferndale, Mich., and vice president of Newark Plastics Inc. of Newark, O., has transferred his full time activities to the latter company. He will unify the sales contact, development, experimental and engineering work for both companies, which specialize in the production of molds and accessory tools.

♦

With headquarters at Pittsfield, Mass., John A. Buckley has been appointed merchandise sales manager for the chemical department of General Electric Co. Prior to his appointment he was associated with the sales division of the lamp department at Nela Park, Cleveland.

♦

Formation of Kaye Plastics Corp. has been announced by S. Leon Kaye, who previously was associated with Consolidated Molded Products Corp. and Universal Plastics Corp. The new company's factory is located at Stelton, N. J., near New Brunswick. The mailing address is P. O. Box 1149, New Brunswick, N. J.

♦

Operating out of the Philadelphia office at 3701 North Broad St., Robert S. Sagers has been named as a representative in the Philadelphia area of the Middle Atlantic district of Kennametal Inc., Latrobe, Pa. Allen M. Austin has been appointed an agent in the Kansas City area, part of the Midwestern district. His headquarters will be at 9 North Jefferson St., Chicago.

♦

Previously vice president in charge of sales for Edison General Electric Appliance Co. in Chicago, Ward R. Schafer has been made general sales manager of Ideal Industries Inc. of Sycamore, Ill., manufacturer of electrical and mechanical industrial equipment.

♦

A new district sales and service office has been opened at 107 South Capitol Ave., Indianapolis, by the Wheelco Instrument Co. of Chicago, manufacturer of industrial measurement and control instruments. Under the direction of John E. Anderson, the new office will serve the territories consisting of the greater portion of Indiana, western Ohio and Kentucky. Mr.

Kodak

The Kodak Transfax Process

● so simple to use... ● in so many ways...

Transfax is a white spray, light-sensitive, quick-drying . . . It reproduces designs, legends . . . quickly and accurately . . . on metal, plastic, and many other surfaces.

It's as simple as this...

You spray it on the product-surface. Some surfaces need special primers.

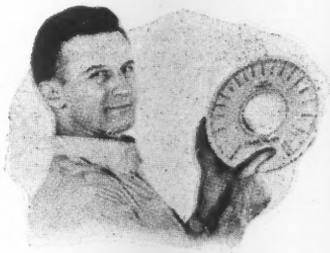
You place a transparent or translucent original on the Transfax-coated surface. You expose to strong light.

You rinse with a weak ammonia solution.

You get a Transfax reproduction of the original quickly . . . inexpensively . . . without a darkroom . . . and the process can be handled by anyone with ordinary skill.

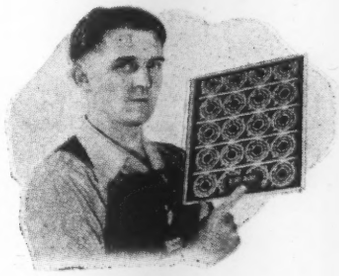
Where a long-life or a wear-resistant finish is desirable, a clear lacquer overcoat should be applied

You can use it like this...

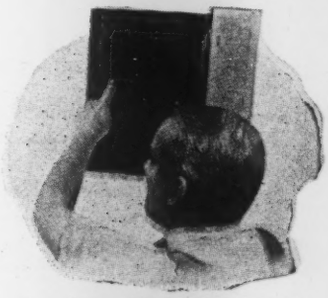


. . . for dials or scales

. . . for fabricating directions



. . . for name plates or monograms



. . . for wiring diagrams

You've seen four of the many possible uses of Transfax. To get information about applying Transfax to your particular needs, write to . . .

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Industrial Photographic Division
Rochester 4, N. Y.

TRANSFAX

Saves Time . . .
Ends Error . . .
Speeds Production

Mail coupon for Free folder

Eastman Kodak Company
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Please send me your free folder on the Kodak Transfax Process.

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Company_____ Department_____

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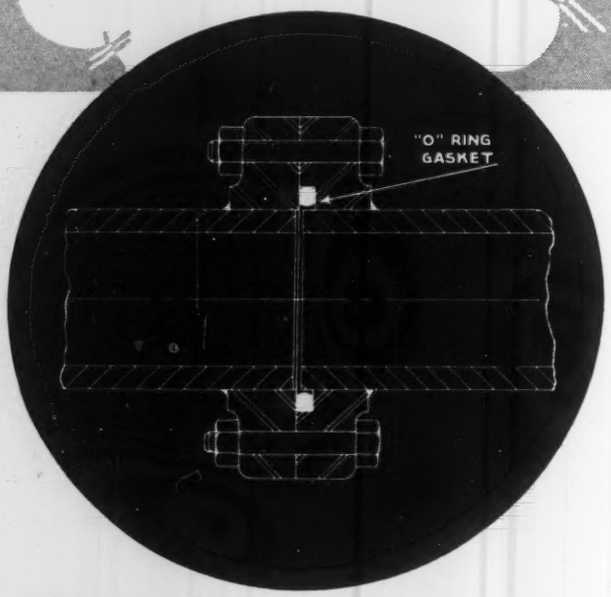
City_____ State_____

19

Stop Blowing Out

AT HIGH PRESSURE



with
LINEAR "O" RING* GASKETS

This Flange Union installation of an "O" Ring Gasket is noted for its ability to hold exceptionally high pressures without blowing out even though the nuts are tightened only sufficiently to maintain metal to metal contact.

Linear "O" Ring Gaskets—moulded synthetic rubber seals—eliminate complicated, bulky assemblies; require no adjustments or mechanical pressure to maintain an effective static seal; relieve unnecessary stresses on your fittings; and can be installed by inexperienced hands.

They are available in standard sizes from ⅛" to 15-½" I.D. and in special sizes as required . . . they are made of general purpose rubber compounds adaptable to a wide range of temperatures, pressures and fluids—or in a number of special compounds to fit your unusual service requirements. To insure a prompt reply to your inquiry, please include a statement of maximum pressure, temperature range and fluid to be handled.

*Covered by Christensen United States Patent No. 2,180,795; all "O" Rings sold by Linear are manufactured under royalty agreement with patentee.

With over 40 years' experience in the design and application of mechanical packings for every purpose, we offer our engineering consultation in connection with your hydraulic design problems. No obligation.

LINEAR
INCORPORATED

Executive Offices and Factory
STATE ROAD and LEVICK STREET—PHILADELPHIA 35, PENNA.

Anderson will be assisted by Walter A. Jones, service engineer at the Indianapolis office, and by L. A. Wallingford, district manager of the Cincinnati office at 831 Temple Bar Bldg.

♦

John J. Wild has been appointed sales manager of Potter Instrument Co., Flushing, N. Y., manufacturer of electronic counting, timing and industrial control equipment. Prior to his appointment Mr. Wild was assistant sales manager of the television equipment sales section of General Electric Co.

♦

Formerly secretary and assistant to the vice president of Oliver Iron & Steel Corp., John P. Roche has been named vice president and general manager of sales of the Heppenstall Co. of Pittsburgh, Bridgeport and Detroit. He also will be made a director of the company.

♦

Appointment of Charles D. Otterson as sales manager has been announced by the Bonney Forge & Tool Works of Allentown, Pa.

♦

With temporary headquarters at Hayden, Colo., Clyde P. Elliott has been named sales engineer of the Colorado, New Mexico, Utah and Wyoming territory of C. P. Clare & Co., Chicago relay manufacturer. A permanent office will be established in Denver in the spring.

♦

A branch plant has been opened at 620 Buffalo Rd., Rochester, N. Y., by Lindberg Steel Treating Co. of Chicago. The plant offers the most complete heat treating services available in the territory.

♦

Homar A. Goddard has succeeded S. A. Newman as assistant division manager in charge of industrial lubricating sales for the Pittsburgh division of Gulf Oil Corp., covering western Pennsylvania and West Virginia. Mr. Newman has been promoted to the position of chief turbine lubrication engineer in the general office of the company.

♦

Seven new welding sales engineers have been appointed by The Lincoln Electric Co. of Cleveland to aid in extending service to all users of electric arc welding. They are: Marvin Anderson, Moline, Ill., office; Albert Bavaria, Philadelphia office; Richard Freundlich, Cleveland office; Paul Holden, Franklin, Pa., office; Richard Nelson, Syracuse, N. Y., office; Richard K. Reynolds, Detroit office; and John E. Williams, Syracuse, N. Y., office.

♦

Previously located at 3945 North Western Ave., Chicago 18, the Sandee Mfg. Co. has moved to 5050 Foster Ave., Chicago 30.

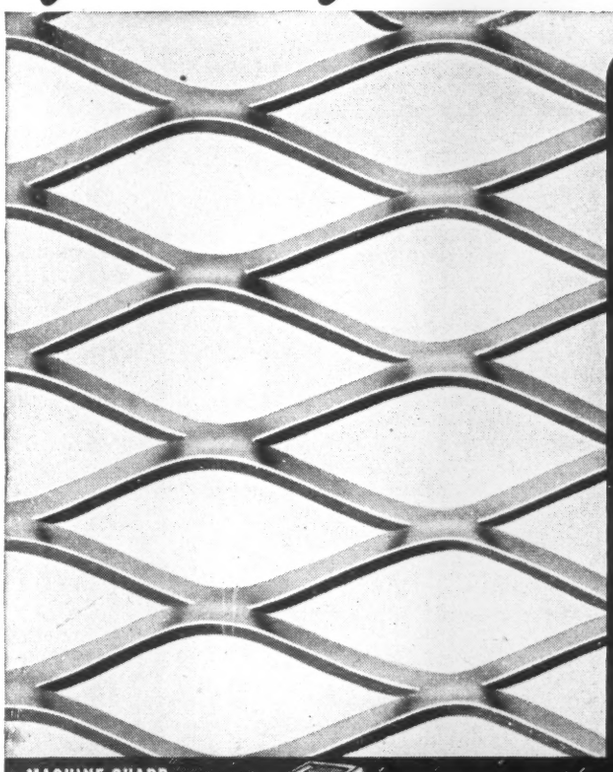
♦

W. Herbert Everitt has been appointed sales representative for Hydropress Inc. of New York, builder of hydraulic presses, rolling mills and die casting machines. Mr. Everitt will handle the states of Washington, Oregon and British Columbia, with headquarters in Seattle at 1743 First Ave. South.

♦

Opening of Chicago and Milwaukee sales offices has been announced by Durant Mfg. Co., manufacturer of Productimeter counting and measuring devices for industrial use. The Chicago office at 224 South Michigan Blvd. is under the management of Orville E. Paramore and covers metropolitan Chicago, Cook County and adjacent counties in Illinois and Indiana. The Mil-

light weight with STRENGTH

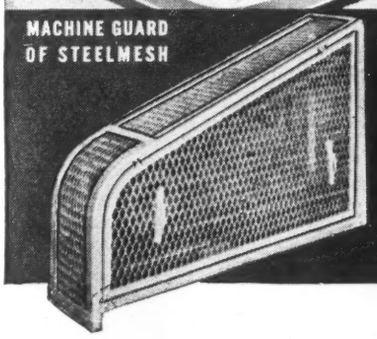


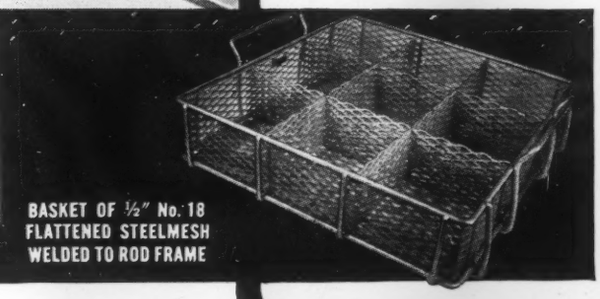
Penmetal Steelmesh

EXPANDED METAL

One square foot of steel plate is expanded to become four to five square feet of Penmetal Steelmesh. No steel waste. The truss-like formation is actually more rigid than the original plate. By using Penmetal Steelmesh for certain parts, a household article has just been designed with a saving of 25% in the total weight. Can be cut, shaped and arc or resistance welded without raveling or joint failures.

Investigate the advantages of Penmetal Steelmesh in the fabrication of your product. *Write for catalog and samples.*





APPROXIMATE SIZES, DIMENSIONS AND WEIGHTS

Style Designation	STANDARD STEELMESH: U. S. Standard Gauge Steel Used	Weight in Lbs. Per Sq. Ft.		Stock Sizes of Sheets	Size of Mesh from Centers of Bridges		FLATTENED STEELMESH: Weight in Lbs. Per Sq. Ft.		Stock Sizes of Sheets	Size of Mesh from Centers of Bridges	
		Plain	Galv.		Width	Length	Plain	Galv.		Width	Length
½"–#20	20	.50	.63	3′ & 6′ x 8′	.45″	1.2″	.47	.63	3′ & 4′ x 8′	.46″	1.28″
½"–#18	18	.74	.91	3′–4′ & 6′ x 8′	.45″	1.2″	.70	.91	3′ & 4′ x 8′	.46″	1.28″
½"–#16	18	.81	.97	4′ x 8′	.45″	1.2″	.77	.97	4′ x 8′	.46″	1.28″
¾"–#16	16	.50	.59	3′–4′ & 6′ x 8′	.95″	2.0″	.47	.59	3′ & 4′ x 8′	.97″	2.13″
¾"–#13	13	.80	.92	3′–4′ & 6′ x 8′	.95″	2.0″	.76	.92	3′ & 4′ x 8′	.97″	2.13″
1½"–#18	18	.20	.25	2′ & 4′ x 8′	1.34″	3.0″	.....	.....	.....	.....	.....
1½"–#16	16	.40	.48	2′ & 4′ x 8′	1.34″	3.0″	.38	.48	2′ & 4′ x 8′	1.34″	3.20″
1½"–#13	13	.60	.68	4′ & 6′ x 8′	1.34″	3.0″	.57	.68	3′ & 4′ x 8′	1.34″	3.20″
1½"–#10	13	.79	.89	4′ & 6′ x 8′	1.34″	3.0″	.75	.89	3′ & 4′ x 8′	1.34″	3.20″

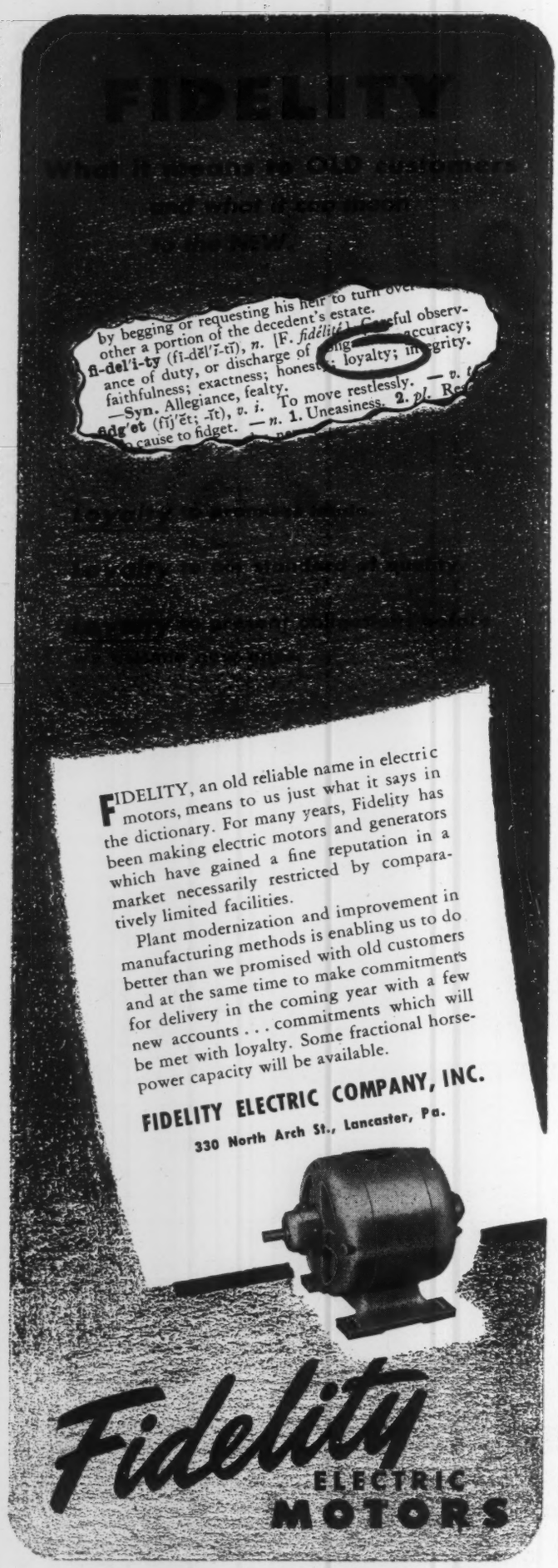
PENN METAL COMPANY, INC.

Dept. 30, Parkersburg, W. Va.

District Sales Offices

BOSTON • NEW YORK • PHILADELPHIA • CHICAGO • DETROIT • PARKERSBURG, W. VA
LOS ANGELES • SAN FRANCISCO • DALLAS

METAL MARK Penmetal 1869 OF QUALITY



waukee office, located at the company address at 1929 North Buffum St., is under the direction of E. W. Crane and covers the east and middle sections of Wisconsin and bordering counties in Illinois.

♦

Goodyear Tire & Rubber Co. has named H. S. Quackenbush and C. B. Quillian to serve as manufacturers' sales representatives at San Francisco and Seattle, respectively. James A. Loder has been appointed manager of commercial sales at the home office in Akron, to replace E. R. Preston who died recently.

MEETINGS AND EXPOSITIONS

Jan. 14-17—
National Materials Handling Exposition to be held at Public Auditorium, Cleveland. Additional information may be obtained from Clapp & Poliak Inc., 37 Wall St., New York.

Jan. 23-26—
Society of the Plastics Industry. Second conference and exhibit of the Low-Pressure Division to be held at Edgewater Beach Hotel, Chicago. W. T. Cruse, 295 Madison Ave., New York, is executive vice president of the society.

Jan. 27-31—
American Society of Heating and Ventilating Engineers. Fifty-third annual meeting to be held in conjunction with seventh international heating and ventilating exposition at Lakeside Hall, Cleveland. Charles F. Roth, Grand Central Palace, New York, is manager of the exposition.

Jan. 28-29—
National Warm Air Heating & Air Conditioning Association. Thirty-third annual meeting to be held at Hotel Cleveland, Cleveland. George Boeddener, 145 Public Square, Cleveland 14, is managing director.

Feb. 24-28—
American Society for Testing Materials. Spring meeting to be held at Benjamin Franklin Hotel, Philadelphia. Technical feature of the meeting will be a symposium on testing and evaluation of paints and paint materials. R. J. Painter, 1916 Race St., Philadelphia 3. is assistant to the secretary.

March 22-27—
Fifth Western Metal Congress and Exposition, sponsored by American Society for Metals, to be held in the San Francisco-Oakland Golden Gate area. Technical meetings and industrial exhibits will be at the Oakland Civic Auditoriums. W. H. Eisenman, secretary of the society and managing director of the congress and exposition, will be available for further information at Hotel Leamington, Oakland, Calif.

March 31-April 2—
Midwest Power Conference, sponsored by Illinois Institute of Technology, to be held at Palmer House, Chicago. Professor Stanton E. Winston, Illinois Institute, is conference director.

April 7-10—
National Association of Corrosion Engineers. Annual convention to be held at Palmer House, Chicago. Elton Sterrett, 905 Southern Standard Bldg., Houston 2, Tex., is executive secretary.

April 9-11—
Society of Automotive Engineers Inc. National aeronautic meeting (spring) to be held at Hotel New Yorker, New York. John A. C. Warner, 29 West 39th St., New York 18, is secretary and general manager.

May 6-10—
Second National Plastics Exposition to be held in conjunction with the annual meeting of the Society of the Plastics Industry. Conference headquarters will be at Stevens Hotel, Chicago, and exposition will be at Chicago Coliseum. William T. Cruse, 295 Madison Ave., New York 17, is executive vice president of the society.

Beauty and Utility in the Modern Kitchen

Here is super-modernity in its newest form. This design of tomorrow's kitchen for small apartments shows an overhead arrangement of sink, range and refrigerator, all operated hydraulically by the mere pressure of a button. Such revolutionary innovations are rapidly sweeping around the world. More and more are light alloys engineered and fabricated by the Bohn organization being used in new developments. Here at Bohn we are thoroughly familiar with what can and what cannot be accomplished with aluminum and magnesium. Let us advise you how these modern light alloys can be put to practical use—increasing the usefulness and saleability of your product. Bohn engineers and metallurgists are at your service. Our many years of practical experience are at your disposal. Maybe now is the right time for you to write us.

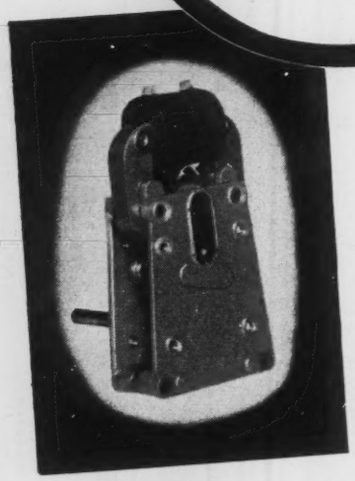
BOHN

BOHN ALUMINUM & BRASS CORPORATION

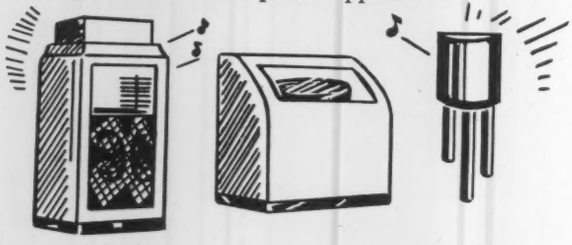
General Offices
Lafayette Building, Detroit 26, Mich.

Designers and Fabricators—ALUMINUM • MAGNESIUM • BRASS • AIRCRAFT-TYPE BEARINGS

This Low-Cost "EMC" Model 300 Motor May Solve Your Power Problem, Too



IF YOU NEED a compact little motor, delivering a slow speed output from 1 r.p.m. up, with a minimum of torque, this E.M.C. Model 300 should fill the bill. With its built-in gear train and adaptability for various voltages, it is ideal for powering coin-operated machines, novelty animated displays, nut-roasting equipment, door-chime closing contacts, — a variety of similar low power applications.



DESIGNED for alternating current only, the Model 300 can be wound for almost any voltage you desire. The most popular windings are for 13, 45, or 115 volts - 60 cycle. It is a 2 Pole, shaded Pole brushless motor without radio interference. The shaft dimensions are changed according to the requirements you specify. A very economical unit to install and operate. Three sizes are available.

PROMPT DELIVERY can be made of any size Model 300 Motor. Tell us your requirements and we will give you detailed recommendations.

TRADEMARK EMC REGISTERED

ELECTRIC MOTOR CORPORATION
Division Howard Industries, Inc.
Racine, Wisconsin

CUSTOM-BUILT FRACTIONAL H.P. MOTORS FOR ALL INDUSTRY

NEW MACHINES

And the Companies Behind Them

Agricultural

Lightweight "between the rows" garden tractor, Special Products Div., Lodge Shipley Machine Tool Co., Cincinnati.
Sub-surface tiller, Graham-Paige Motors Corp., Willow Run, Mich.

Air Conditioning

Room conditioners, York Corp., York, Pa.
Electric heating fan for winter and cooling fan for summer, Thermador Electrical Mfg. Co., Los Angeles 22.
Portable dust collector, Dust Filter Co., Chicago.
Self-contained, recirculating type dust collector, Aget-Detroit Co., Ann Arbor, Mich.
Home ventilator, American Blower Corp., Detroit.

Aircraft

Radio range receiver, Lear Inc., Grand Rapids, Mich.
1000-watt amplifiers for vibration testing, Thordarson Electric Mfg. Div., Maguire Industries.
Portable ac-dc receiver, Electronic Specialty Co., Los Angeles.
Airplane with station wagon utility, Stinson Div.. Consolidated Vultee Aircraft Corp., Wayne, Mich.

Industrial Heating

Electrical, cylindrical gas carburizing furnace for temperatures of 1800 F, Industrial Heating Div., General Electric Co., Schenectady, N. Y.
Aluminum melting furnace, The Kindt-Collins Co., Cleveland.
Batch-type furnace for light alloys, Bellevue Industrial Furnace Co., Detroit.
Electric furnace for small parts, Thermo Electric Mfg. Co., Dubuque, Ia.
Combination induction and dielectric heater, Induction Heating Corp., New York 3.
Gas producing equipment, General Electric Co., Schenectady, N. Y.
Doughnut shaped rotary furnace, Rust Furnace Co., Pittsburgh.

Industrial

Precipitator, Koppers Co. Inc., Pittsburgh 19.
Machine for cutting floor tiling from 4 to 24 inches square, in graduations of 1 inch, Campbell Machine & Development Co., Cuyahoga Falls, O.
Unit substations, Wagner Electric Corp., St. Louis 14.
Booster amplifier, David Bogen Co. Inc., New York 12.
Production marking etcher, Ideal Industries Inc., Sycamore, Ill.
Conveyorized one-dip concentrator, Detrex Corp., Detroit.
Indoor and outdoor type induction voltage regulators, General Electric Co., Schenectady, N. Y.
Bench type filter, sealed-disk type for light work, Alsop Engineering Corp., Milldale, Conn.
Oil generating unit, Vapcfier Corp., Chicago 43.

Metalworking

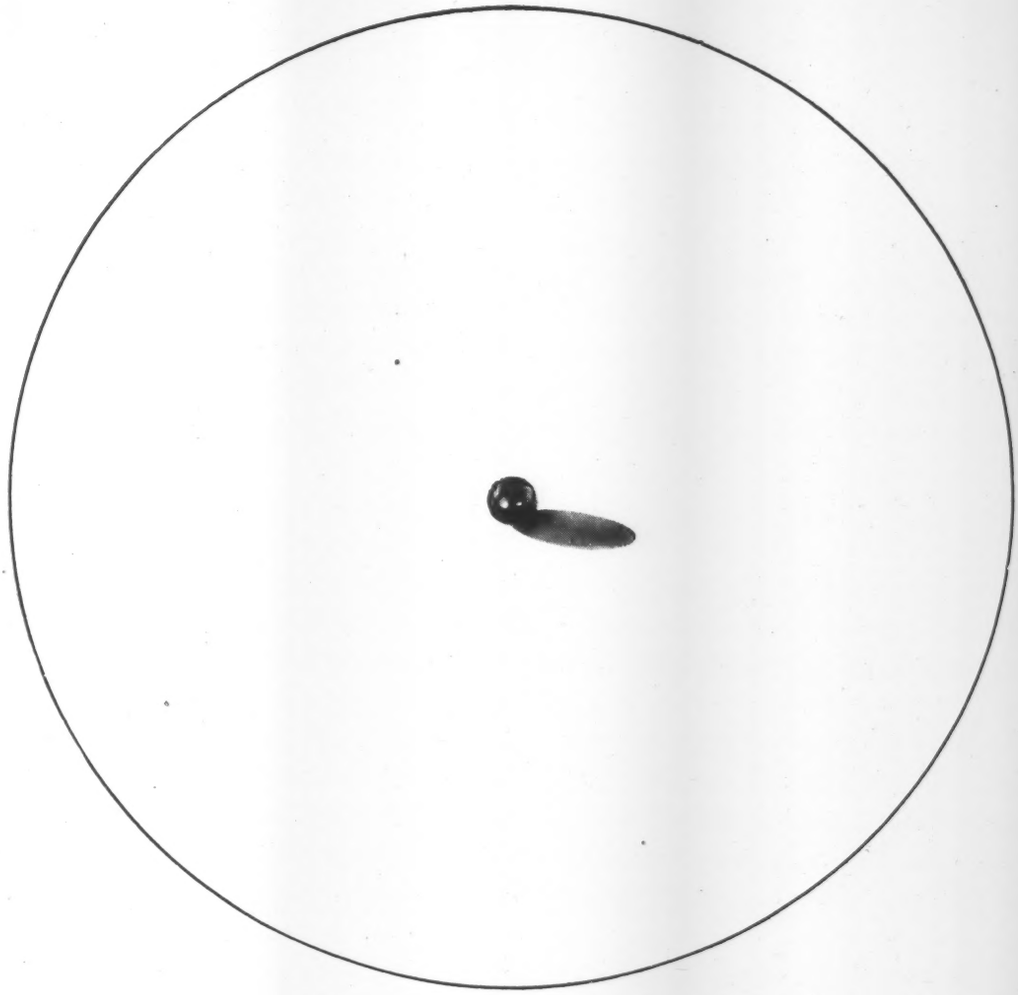
5-37½ ton vertical pull-down broaching machines, The Oilgear Co., Milwaukee 4.
Hydraulic, self-contained, pressure die casting machine, Hydraulic Machinery Inc., Dearborn, Mich.
Drilling machine for three sizes of auto frames, Snyder Tool & Engineering Co., Detroit 7.
4-ton bench punch press, Benchmaster Mfg. Co., Los Angeles.
Grinder for light, medium and high speed work, Wyzenbeck & Staff Inc., Chicago 22.
Special-purpose two-stage miller, Hydraulic Machinery Inc., Dearborn, Mich.
Center drilling machine, Detroit Tap & Tool Co., Detroit 11.
Die casting machine for zinc, lead and tin castings, Light Metal Machinery Inc., Cleveland 13.
Index type milling and spinning machine, Davis & Thompson Co., Milwaukee 14.

Textile

Wool and silk spotting machine, Excelsior Machinery Co., Detroit 26.

Welding

Twin-unit, outdoor ac welder, General Electric Co., Schenectady, N. Y.
Giant portable spot welder for structural steel, Sciaky Bros. Inc., Chicago.
Automatic flash butt welder, DoAll Co., Minneapolis.
Flash welder for heavy aluminum sections, Progressive Welder Co., Detroit 12.
Storage battery powered flash welders, Progressive Welder Co., Detroit 12.
Press-type spot welders, Taylor-Hall Welding Corp., Warren, O.
Ac arc welder, Lincoln Electric Co., Cleveland 1.
Combination gas-electric drive, 300-ampere arc welder, Hobart Bros. Co., Troy, O.
Ac electric arc welders, Hampton Electric Mfg. Co., Pittsburgh 12.



IT TAKES 28 HOURS TO GRIND AND LAP THIS FEDERAL BALL

See this ¼" ball? Twenty-eight hours of grinding and lapping are required to round out its dimensions before it can take its place in a Federal Ball Bearing assembly.

To you as a bearing user that's important, for *only one* bad ball ruins a bearing's efficiency, impairs the performance of your equipment, interrupts production.

But no bad balls can get by the sensitive "fingers" of Federal's electrically controlled inspection gauges. Each ball must be uniformly spherical within .000025" and the variation in diameter in any bearing is not more than .00005". Made of through-hardened chromium alloy steel, each is crush-tested for load-bearing strength, micro-tested to reveal hidden pits or scratches and polished to its lustrous superfinish.

So it goes through every Federal manufacturing step. More than 100 individual production, inspection and cleaning operations go into a single-row radial ball bearing. *Every fourth operator is an inspector.* Add them up and you have *positive* precision performance on production lines everywhere...in machine tools, farm equipment, electric motors, marine equipment, automobiles and airplanes.

That's why, *wherever tolerances are tight,* specify Federal Ball Bearings...in any range or size.

THE FEDERAL BEARINGS CO., INC. • POUGHKEEPSIE, NEW YORK

Makers of Fine Ball Bearings

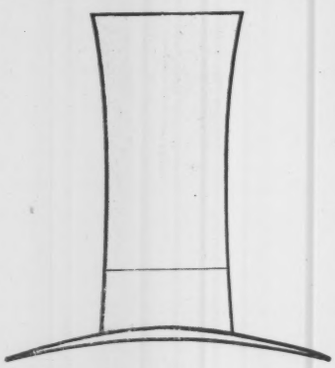
REPRESENTATIVES LOCATED AT

Detroit: 2640 Book Tower–26 • Cleveland: 402 Swetland Building–15
Chicago: 8 S. Michigan Ave.–3 • Los Angeles: 5410 Wilshire Blvd.–36

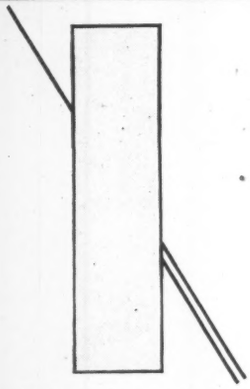
FEDERAL BALL BEARINGS

ONE OF AMERICA'S LEADING BALL BEARING MANUFACTURERS

How is Your "Eye Cue" on Measurements?



A. How does the vertical dimension compare with the horizontal?



B. Which oblique line on right is a prolongation of that on left?

C. What size is this Socket Screw?

A surprising number of seasoned shop men discovered that eye cues to sizes are not always reliable. In several tests made recently, many failed to identify the correct size and thread pitch of the socket screw above. Ordinarily these men don't guess... they take the sure but slow way of gauging or "miking".

Now...they're sure at a glance...

WHEN IT'S SIZE-MARKED

This unique improvement appears on the head of every P-K Socket Head Cap Screw. It saves time by eliminating gauging or "miking" and removes every possibility of error.

At the tool crib, left-over mixed-up screws are quickly identified and replaced in the right bins. Correct sizes are issued to assembly line workers – speeding up their work. New help learns screw sizes faster – works faster.

AN EXTRA SALES FEATURE, TOO. Service men in the field recognize its time-saving advantages on re-assembly jobs.

Plus ANOTHER IMPROVEMENT – GEAR GRIP*

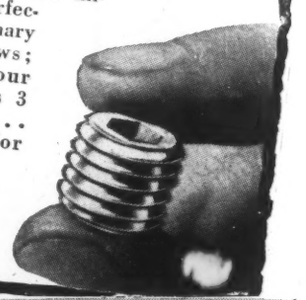
This firm gripping surface prevents slips and slow-downs for fast fingers, even when oily. Only P-K offers Socket Head Cap Screws with both features. Write for samples, today. Parker-Kalon Corp., 200 Varick Street, New York 14, N. Y.

ANSWERS: **A. The same B. The lower one**
C. When it's P-K Size-Marked, there's never a question!

ANOTHER P-K FIRST!
Ground Thread Socket Set Screws

• Threads are ground on pre-hardened stock by a newly developed centerless grinding method. The results . . . a smoother, brighter, cleaner finish, free from imperfections common to ordinary cut thread set screws; faultless thread contour and dependable Class 3 Fit. They look better . . . start better. Write for samples.

P-K SOCKET SCREWS ARE AVAILABLE FOR PROMPT DELIVERIES



*U. S. PAT. No. 126,409

SOLD ONLY THROUGH ACCREDITED DISTRIBUTORS

PARKER-KALON *Cold-forged* SOCKET SCREWS

Won't Come Off

ALL ONE PIECE

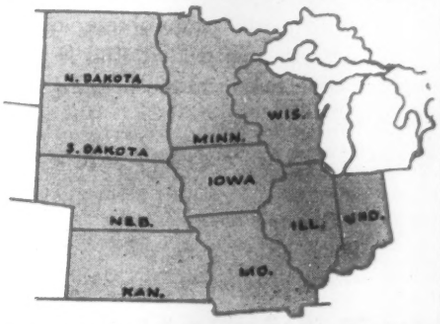
The fins on this Wolverine TRUFIN are extruded from the tubing itself—thus the fins and body are one and the same metal. The fins cannot come off.

That is one of the main reasons why TRUFIN is selected for use in equipment where heat transfer is required—especially in cases where vibration may be encountered.

Because TRUFIN presents nearly four times the surface area of plain tube, it is obvious that this tube can do a better job in much less space than is possible with plain tube.

TRUFIN is available in a variety of fin spacings, heights and alloys. It can be bent and formed nearly as readily as plain tube.

WHO'S WHO AMONG WOLVERINE REPRESENTATIVES



G. D. POTTER
STEEL SALES CORP., 3348 S. PULASKI ROAD, CHICAGO 23, ILLINOIS

Serves the States of: Illinois, Indiana (except cities of Evansville, Jeffersonville and New Albany), Wisconsin, Missouri, Iowa, Minnesota, North Dakota, South Dakota, Nebraska, Kansas.

Send for Wolverine Trufin Data; Forms 651 and 652. This information will be sent on request without charge or obligation.

WOLVERINE
TUBE DIVISION

CALUMET & HECLA CONSOLIDATED COPPER COMPANY

1411 CENTRAL AVENUE • DETROIT 9, MICHIGAN

℞ for long life...

in anti-friction bearings, proper attention to lubrication is essential. With Torrington Needle Bearings efficient lubrication is almost automatically assured.

A drop or two as required...

may be the "prescription" for your application and often no additional lubricant is needed after the initial installation. For in Torrington *Needle* Bearings the lubricant *lasts* for a long period. Because the turned-in lips of the retaining shell provide a natural reservoir for oil or grease, an *extra margin* of safety is provided. This is another Needle Bearing feature that is contributing to their record of long service life and low in-use cost.

THE TORRINGTON COMPANY

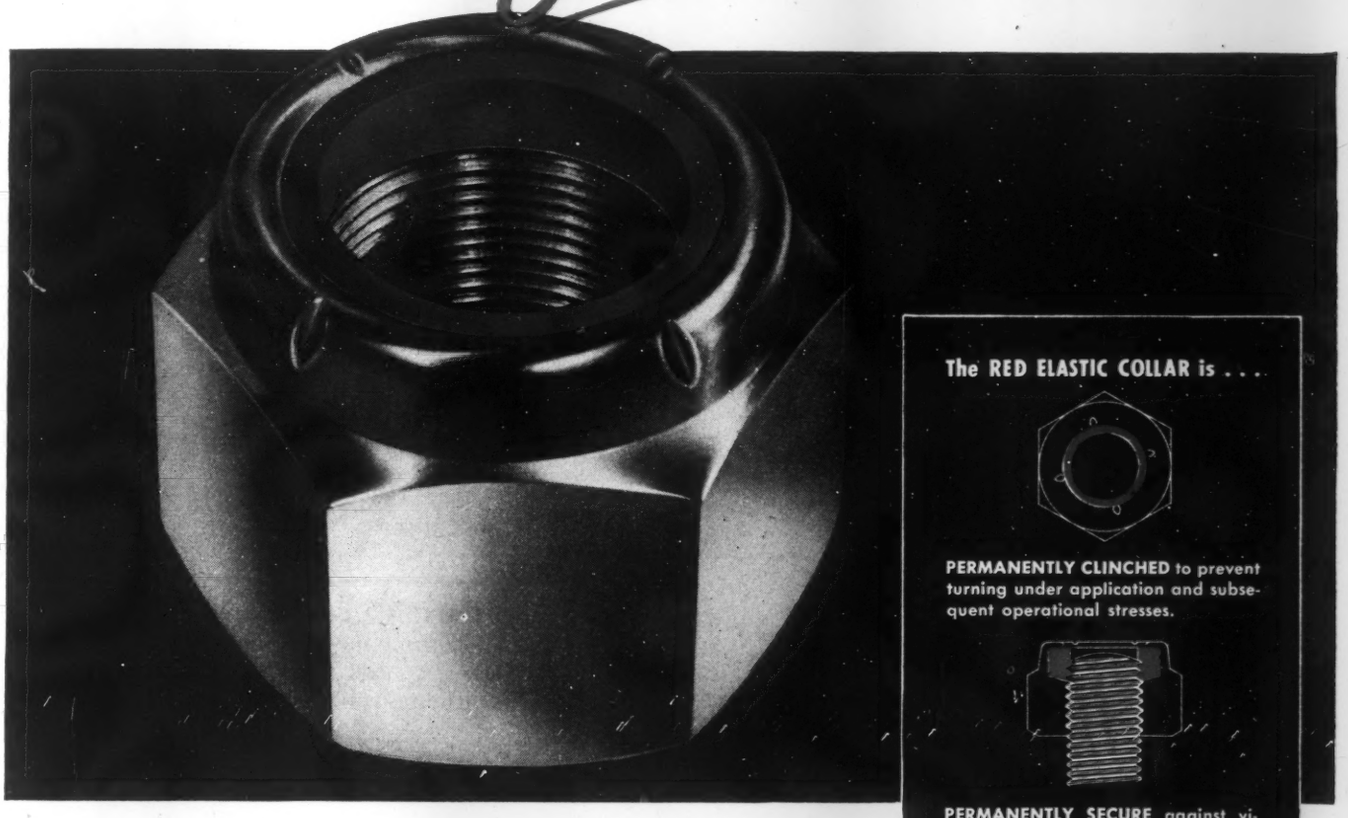
TORRINGTON, CONN. SOUTH BEND 21, INDIANA

Offices in all principal cities

TORRINGTON BEARINGS

• NEEDLE • SPHERICAL ROLLER • STRAIGHT ROLLER • TAPERED ROLLER • BALL •

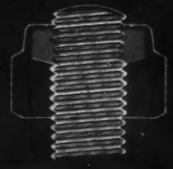
THE FAMOUS *Red Elastic Collar* IS A SYMBOL OF SECURITY



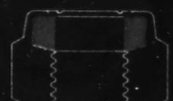
The RED ELASTIC COLLAR is . . .

PERMANENTLY CLINCHED to prevent turning under application and subsequent operational stresses.

PERMANENTLY SECURE against vibration effects. The bolt impresses (does not cut) full contact threads.



PERMANENTLY TIGHT against moisture. Bolt threads have 100% contact in collar — and a full metal seat.



REUSABLE. The Red Elastic Collar retains its grip after repeated usage.

It makes ESNA *Elastic Stop Nuts Self-Locking, Self-Sealing and Reusable*

As a result, all ESNA Elastic Stop Nuts protect assemblies against the effects of: VIBRATION: Elastic Stop Nuts lock in position anywhere on a bolt or stud. Vibration, impact or stress reversal cannot disturb prestressed or positioned settings. . . . CORROSION: Elastic Stop Nuts keep the working threads on the bolt and nut bright and rust-free to protect their strength and permit easy removal without damage to the bolt. . . . THREAD FAILURE: Elastic Stop Nuts dampen impact stresses and materially reduce the shocks against bolt threads that frequently cause metal fatigue. . . . LIQUID SEEPAGE: Elastic Stop Nuts produce a radial-reactive pressure against the bolt threads inside the Red Elastic Collar that makes Elastic Stop Nuts self-sealing against liquid seepage. . . . COSTLY MAINTENANCE: Elastic Stop Nuts are reusable. (Torque tests on aircraft bolts prove that adequate locking torque is maintained through 15 on-and-off cycles.) They do not deform the bolt, damage the threads, gall the finish, or rust.

This wide range of protection permits full purchasing and inventory standardization and its resultant economy. For further information address: Elastic Stop Nut Corporation of America, Union, New Jersey. Sales Engineers and Distributors are conveniently located in many principal cities.

ESNA ELASTIC STOP NUTS

TRADE MARK

INTERNAL WRENCHING

ANCHOR

WING

SPLINE

CLINCH

GANG CHANNEL

CAP

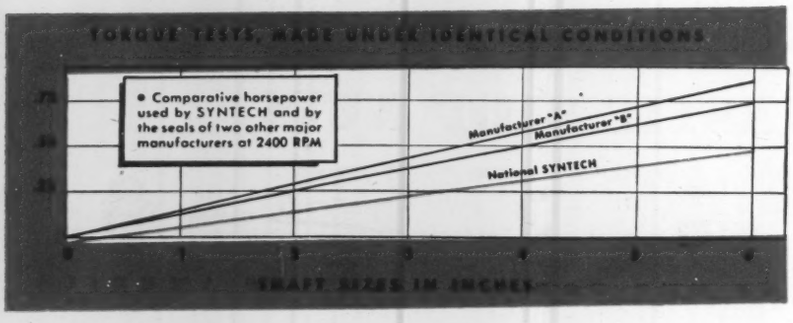
PRODUCTS OF: ELASTIC STOP NUT CORPORATION OF AMERICA

Syntech* the National Oil Seal drag, yet seals

DYNAMOMETER and road tests prove this new National SYNTECH Oil Seal a revolutionary achievement in oil retention.

The chart below shows the amazing reduction in drag achieved when National SYNTECHS, with their tough, new synthetic-rubber sealing members, are put on the job. Safety factors on speed, runout, abrasion and wear far surpass any other seal tested. And grueling "destruction" runs prove positively that National SYNTECHS perform at *zero leakage* up to 10 times the life of a normal application.

Write today for samples and more information on the new National SYNTECH Oil Seal—a great contribution to the mechanical industry.

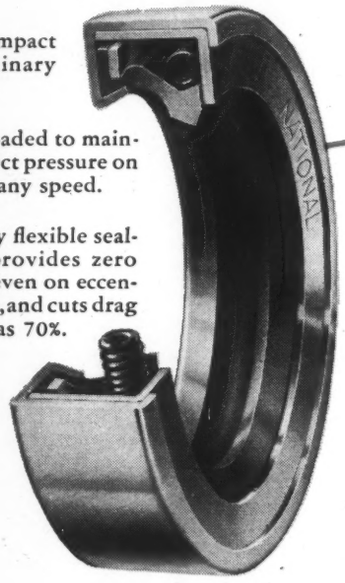


* **SYNTECH** (trademark registered) is an entirely new oil seal which utilizes a special National-developed, synthetic-rubber sealing member.

More compact than ordinary oil seals.

Spring-loaded to maintain correct pressure on shafts at any speed.

Extremely flexible sealing lip provides zero leakage, even on eccentric shafts, and cuts drag as much as 70%.

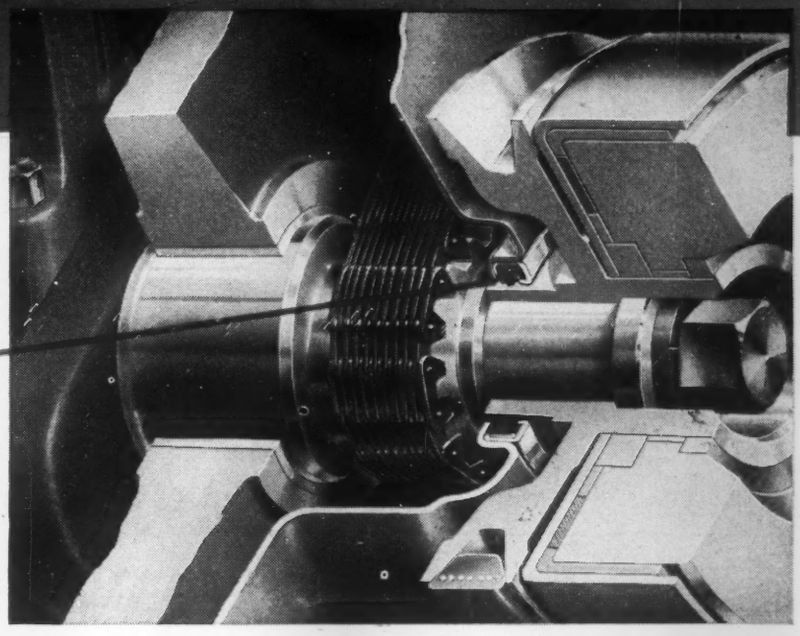


SYNTECH is made of synthetic rubber compounded to achieve high flexibility and low coefficient of friction.

Design of sealing lip provides limited shaft contact.

This thin section assures maximum flexibility of the sealing member.

Amazing New which cuts down better, longer!



New National Syntech Oil Seals Last 100% Longer on This Diesel Engine Installation

A major diesel engine manufacturer recently tested leading oil seals to find which was best able to take the hard knocks handed out in the chain drive case.

Tests included a "destructive" endurance run at shaft speeds of 2600 FPM, temperatures up to 275° F., and 015" eccentricity.

The result? National SYNTECHS got the job! Why? Because these revolutionary synthetic-rubber seals maintained perfect oil retention while lasting more than 100% longer than the next best oil seal tested!

No matter what type of mechanical equipment you may be working on—if it has moving shafts—you should avail yourself of full information about the new National SYNTECH Oil Seal. Our engineers are at your service. Details of your problem will be held in strictest confidence.

NATIONAL MOTOR BEARING COMPANY, INC.
General Offices: Redwood City, California
Plants: Redwood City, and Los Angeles, Calif.
Van Wert, Ohio

NATIONAL
OIL AND FLUID SEALS

WHEREVER SHAFTS MOVE, THERE'S A NATIONAL SEAL TO RETAIN THE LUBRICANT

CALL IN A NATIONAL ENGINEER FOR RECOMMENDATIONS

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Phone: Central 8663-8664

Room 1026 Fisher Bldg., Detroit 2
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1717 E. Kane Place, Milwaukee 2
Phone: Lakeside 2838

124 State St., Springfield 3, Mass.
Phone: Springfield 2-1881

401 North Broad St., Philadelphia 8
Phone: Bell-Walnut 2-6997—6998

122 East 42nd St., New York City 17
Phone: Lexington 2-8260

210 Heights Rockefeller Bldg., Cleveland, 18
Phone: Yellowstone 2720

1 Main St., Houston 2, Texas
Phone: Preston 9862

1823 Walnut, Kansas City 8, Mo.
Phone: Harrison 6637

Short story on superiority

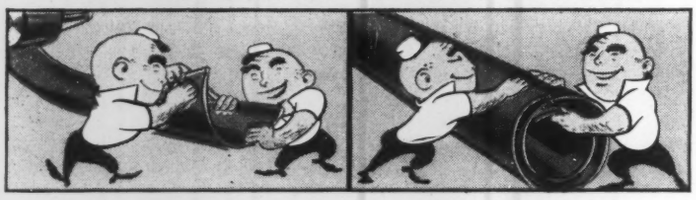
1 Solid double wall construction provides **HIGH FATIGUE STRENGTH** when you specify Bundyweld Steel Tubing.

2 And the use of close tolerance cold rolled strip in this unique tubing means **PRECISE DIMENSIONS.**

3 Because it's extra tough, Bundyweld gets wide recommendations for **RESISTANCE TO BURSTING** in pressure applications.

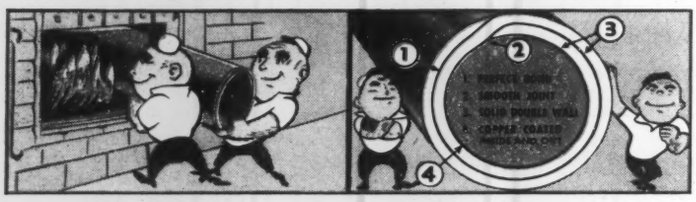
4 Finally, Bundyweld combines strength with great **DUCTILITY** to offer extreme ease in fabrication.

WHY BUNDYWELD IS BETTER TUBING



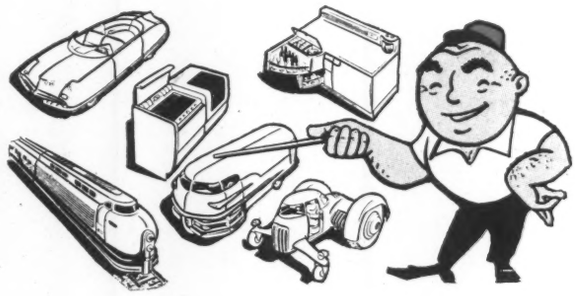
1 Bundyweld Steel Tubing is made by a process entirely different from that used in making other tubing. A single strip of copper-coated S.A.E. 1010 steel is continuously rolled twice laterally . . .

2 . . . into tubular form. Walls of uniform thickness and concentricity are assured by the use of close tolerance cold rolled strip. This double rolled strip passes through a furnace where the . . .



3 . . . copper coating fuses and alloys with the double steel walls. After brazing and cooling, it becomes a solid double wall steel tube, copper brazed throughout 360° of wall contact . . .

4 . . . copper coated inside and out, free from scale, closely held to dimensions. Hard or annealed in standard sizes up to ⅝" O.D. Special sizes cold drawn. Also in Monel, nickel and nickel alloys.



5 That's why Bundyweld is specified for hundreds of modern products ranging from refrigerators and gas ranges to motor vehicles and Diesel engines. Wherever the call is for outstanding mechanical properties, investigate Bundyweld Steel Tubing. Also available in nickel and Monel. Write: *Bundy Tubing Company, Detroit 14, Michigan.*

BUNDY TUBING

ENGINEERED TO YOUR EXPECTATIONS

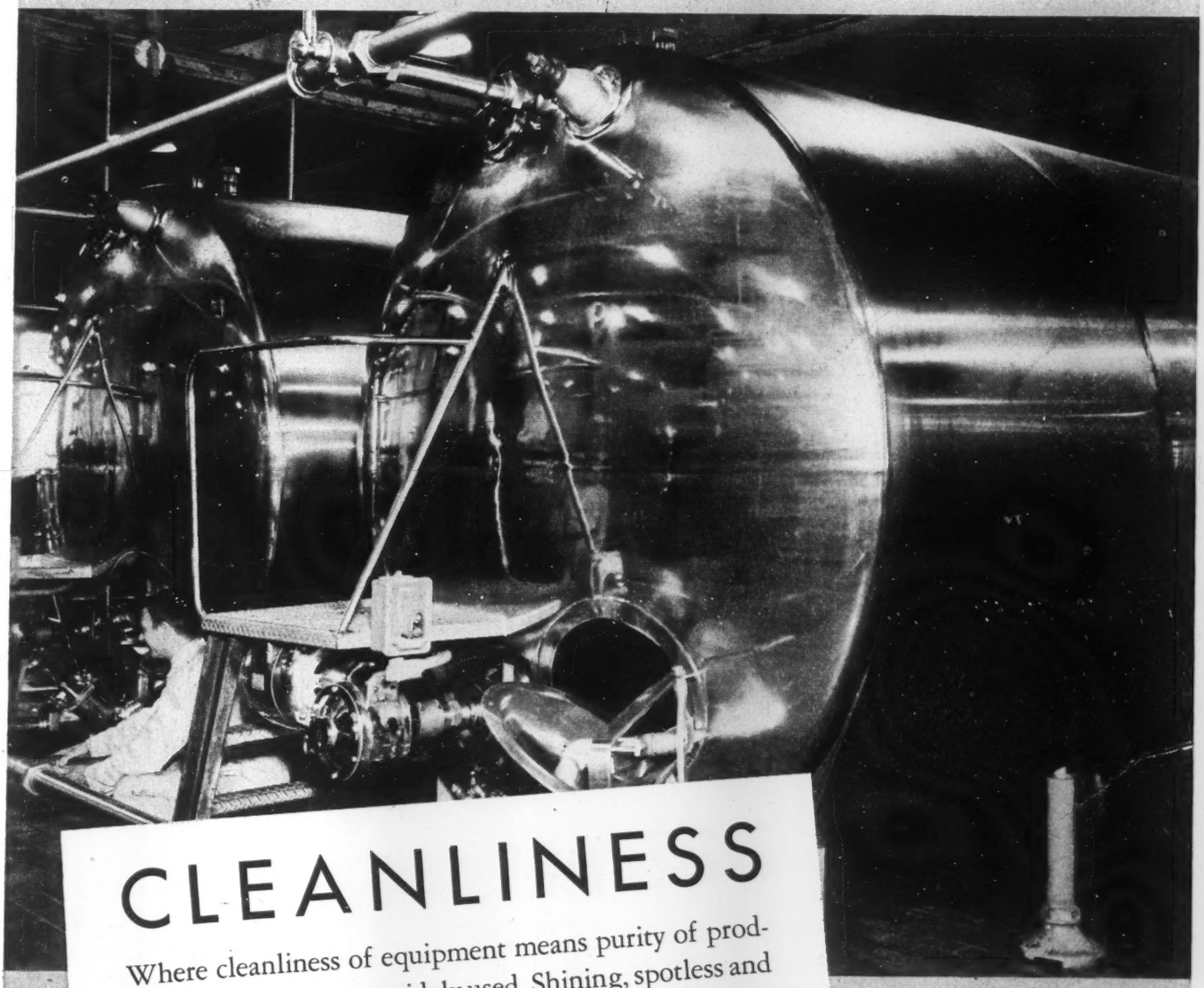
BUNDY TUBING DISTRIBUTORS AND REPRESENTATIVES:

Pacific Metals Co., Ltd. 3100 19th St. San Francisco 10, Calif.	Standard Tube Sales Corp. 1 Admiral Ave. Maspeth, N.Y.C., N.Y.	Lapham-Hickey Co. 3333 W. 47th Place Chicago 32, Illinois	Rutan & Co. 404 Architects Bldg. Phila. 3, Pa.	Eagle Metals Co. 3628 E. Marginal Way Seattle 4, Wash.	Alloy Metal Sales Ltd. 861 Bay St. Toronto 5, Canada

Wichita City Libr

CHROMIUM-NICKEL AUSTENITIC STAINLESS STEELS

Most versatile of modern metals . . . their unique combinations of properties merit your consideration in designing for the future.

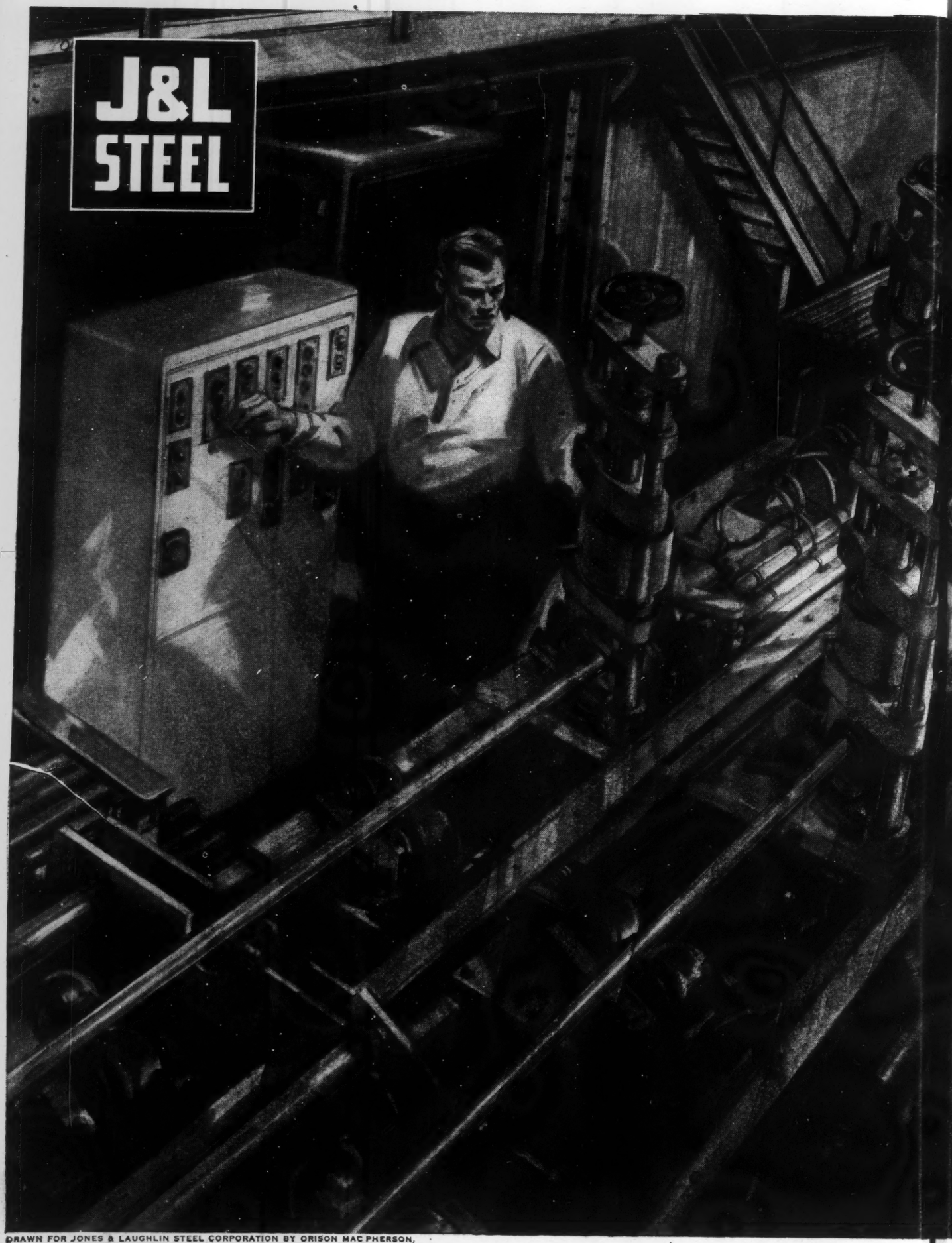


CLEANLINESS

Where cleanliness of equipment means purity of product, stainless steels are widely used. Shining, spotless and hygienic, inside and out, these chromium-Nickel stainless steel milk storage tanks guard purity at Sheffield Farms Co., Inc., Division of National Dairy Products Corp., Jamaica, Long Island, N. Y.

International Nickel are miners, smelters, and refiners of Nickel, an important ingredient in the chromium-Nickel austenitic stainless steels. Although they do not produce these stainless steels, a list of the sources of supply will be furnished on request.

THE INTERNATIONAL NICKEL COMPANY, INC. 67 Wall Street New York 5, N.Y.



DRAWN FOR JONES & LAUGHLIN STEEL CORPORATION BY ORISON MAC PHERSON,

NOW, ELECTRONICS GOES TO WORK FOR J&L TO HEAT TREAT COLD FINISHED STEEL UNIFORMLY

Electronics, a fast, powerful, new industrial servant, has been put to work by Jones & Laughlin Steel Corporation in the electric induction heat treatment of cold finished steel bars for the first time by any steel producer. These new "Electreat" steel bars have a degree of uniformity not achieved by conventional furnace heating and tank quenching methods.

In the J&L "Electreat" process each bar is heated and quenched individually in exactly the same length of time as other bars in the lot. This is accomplished through the unusually accurate control of heating and quenching provided by the induction method. Yet "Electreat" bars retain their sectional accuracy and quality surface. Induction heating also keeps to a minimum decarburization which may cause uneven wear in a finished part. "Electreat" bars in a variety of sizes are available in a wide range of quenched and tempered treatments.

Application of induction heating to provide uniform cold finished bars with better physical properties accents J&L's leadership in cold finishing steel, invented by J&L and patented in 1859.

JONES & LAUGHLIN STEEL CORPORATION

PITTSBURGH

"ELECTREAT" STEEL

Smart design and production engineers step up their production and cut out costly heat treating operations by using quenched and tempered cold finished steel for parts of autos, domestic appliances, business machines and many other applications. By using bars heat treated for them in the steel mills they gain advantages of increased strength, ductility, hardness, toughness without necessity of heat treating the finished part in their own plants. This also removes possibility of distorting the article after intricate machining work has been completed. They now will find that J&L "Electreat" bars give them additional advantage of increased uniformity over conventional heat treated bars.

Cold finishing, patented by J&L in 1859, improves size accuracy, surface, and physical characteristics of hot rolled steel bars. All the advantages of cold finished steel are retained in J&L "Electreat" process.

Electronic principle of transformer is used in "Electreat" induction heating method. High frequency electric current flowing through a coil transfers to the bar passed through it. The resistance of the bar to the current causes heating to take place with extreme rapidity. In "Electreat" process the bars are fed continuously through an induction coil. Depending upon their size and desired temperature, they are heated in 15 to 25 seconds to about 1600 degrees F. The coil itself, which does not come in contact with the bar, remains cool. In fact, you could place your hand inside and not feel heat, yet if you had on a metal ring it would be melted instantly. When the bars leave the coil they pass through a cone of water sprays which strike the steel at high pressure. This produces a rapid rate of cooling to harden the steel. In cases where this more severe quench will fully harden the section it may be possible to substitute plain carbon steel for a low alloy steel.

Steel can be quenched in many mediums, including air, water, brine, molten salts and various light and heavy oils.

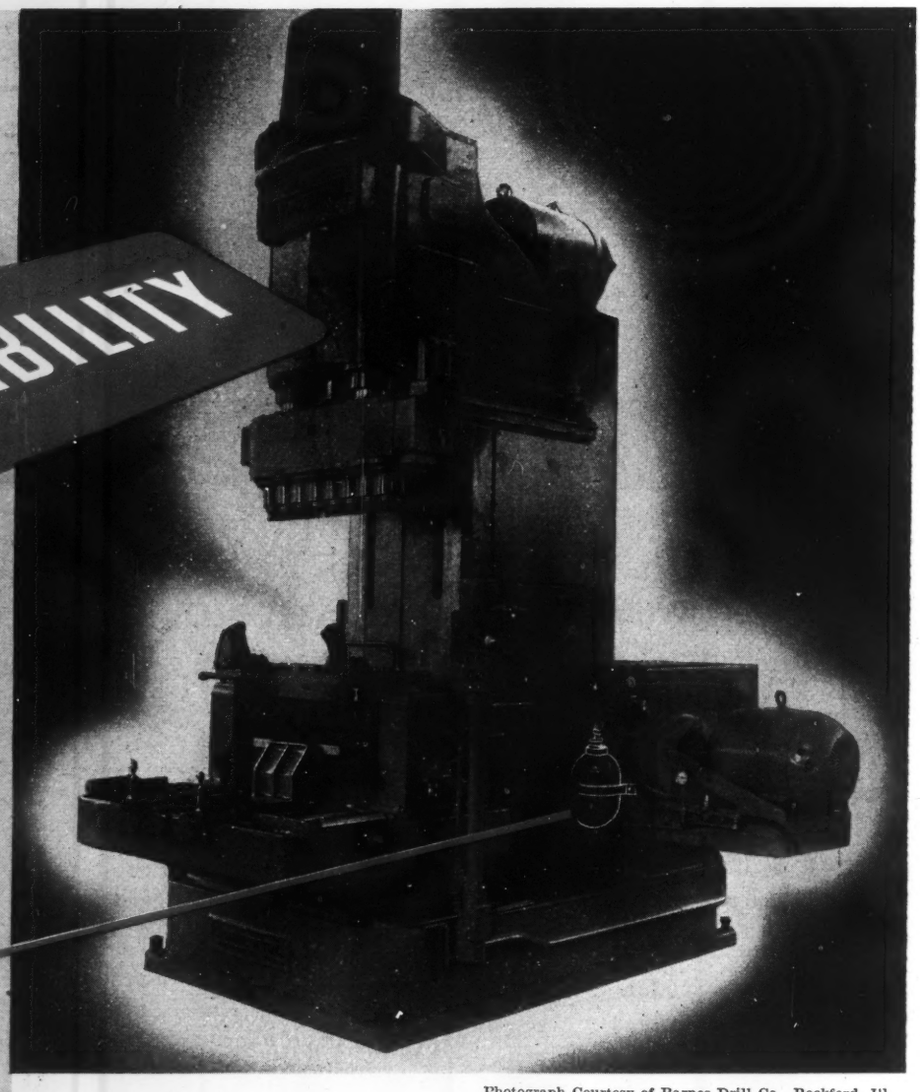
Heat treatment is ancient art, was practiced by mystics and alchemists of the Middle Ages in fashioning armor and swords. Centuries later the village smithy still depended upon his sense of color for his crude but no longer mystic heat treatment. He heated steel in forge to dull red, cherry, or orange, plunged it into oil or water and determined by filing or scratching if steel was quenched to proper hardness.

Father of modern heat treating was Henri le Chatelier (1850-1936) who discovered many new facts about the effect of heating and cooling steel. He started the advancement of heat treating from a hit-and-miss art to an exact science.

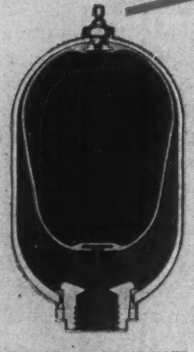
GREER

ADAPTABILITY

TO MODERN INDUSTRY



Photograph Courtesy of Barnes Drill Co., Rockford, Ill.



"PATENT OLAER NUMBER 2256835" "PATENT APPLICATION OLAER SERIAL NUMBER 519762."

MORE POWER TO YOU WITH GREER HYDRAULIC ACCUMULATORS

Maximum power and *dependable car performance* go hand-in-hand with engine cylinders which are perfectly round and straight.

It is *Micromatic Honing* that gets this dimensional accuracy in cylinder bores. This is a precision operation requiring rapid expansion and collapse of the honing tool.

The instantaneous application of power is obtained from the *Greer Hydraulic Accumulator* used with the *Barnesdril* 8-spindle *Automatic Honing Machine* shown above. This machine is used by the *General Motors Corporation* for honing the 8-cylinder engines for the new Oldsmobiles.

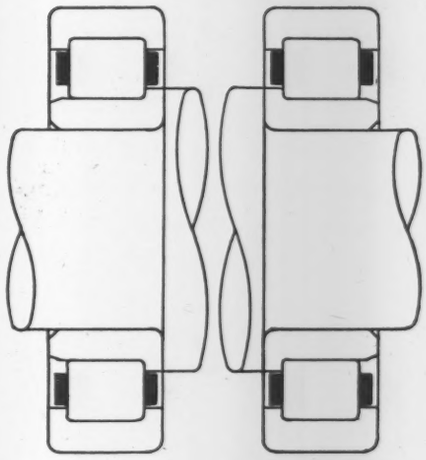
For this and thousands of similar applications, consult our Engineering Department today.

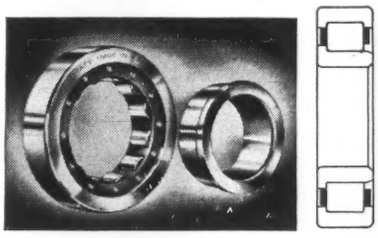
GREER HYDRAULICS INC. 454 15TH ST., BROOKLYN, N. Y.

NEED A RADIAL BEARING THAT WILL ALSO LOCATE THE SHAFT?

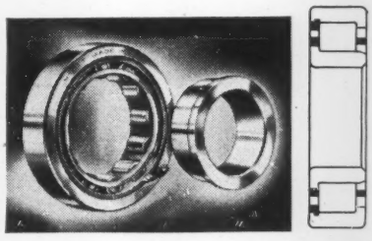
Hyatt has the Answers

Designed for the many applications where the bearing load is primarily radial—but where some provision is needed for axial shaft location—these Hy-Load Bearings serve that double purpose. And when used in pairs, they can locate the shaft in both directions.

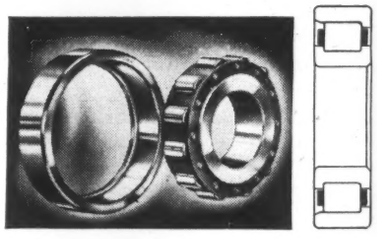




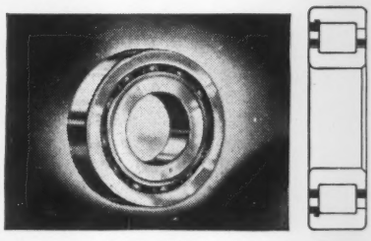
R-WB



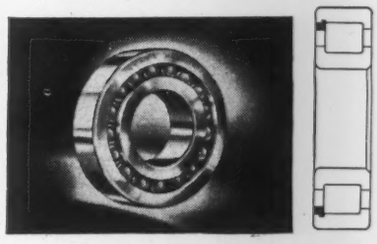
R-YS



BU-L



U-YS



U-YM

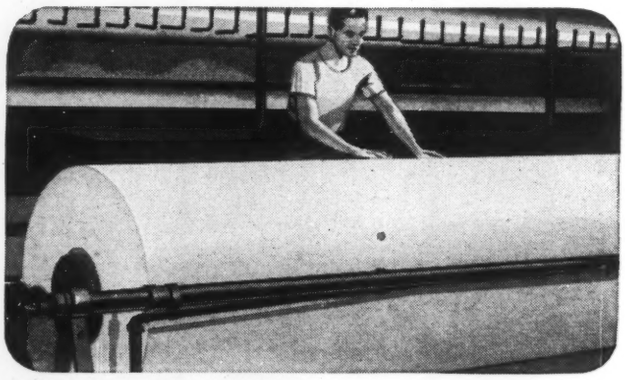
This is but one of the advantages enjoyed by designers who know the Hy-Load line. Others include: option of omitted race operation, complete interchangeability of parts, maximum capacity for standard AFBMA dimensions – and long, trouble-free life.

Full information about all 10 types of Hyatt Hy-Load Bearings (including dimensions and load ratings) is in the new 88-page Hy-Load Catalog . . . a complete engineering guide to radial bearing selection and use. Write now for a free copy, without obligation. Hyatt Bearings Division, General Motors Corporation, Box 71A, Harrison, New Jersey.

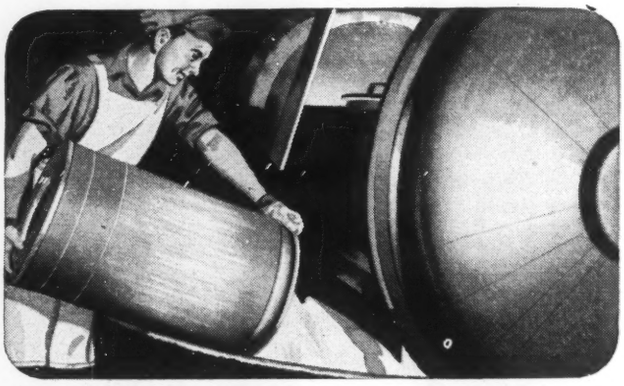
HYATT ROLLER BEARINGS

Watch industry Fluid-Drive* ahead!

1 Cable Manufacturing. Looking for savings? Standard, constant speed AC motors gain new flexibility when equipped with Gýrol Fluid Drive. A vortex of oil takes up the load smoothly—pulls evenly from dead stop to full speed—protects equipment against overloads.

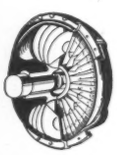


2 Paper. Gýrol Fluid Drive has helped paper manufacturers to simplify equipment and to cut maintenance costs. In this industry Fluid Drive is used to transmit power to slitters, coaters, draft fans, rewinders and conveyors.



3 Plastics. You get adjustable speed control at its best with Gýrol Fluid Drive on extruders, pumps, fans, rotary driers, agitators, crushers and compressors. Here's faster, easier selection of the most efficient speed for a given process.

4 And You? We firmly believe that industry has only started to explore the uses for Gýrol Fluid Drive. *Quite possibly you can find profitable new uses in your plant, processes or product.* Why not investigate the matter with our engineers?



AMERICAN BLOWER

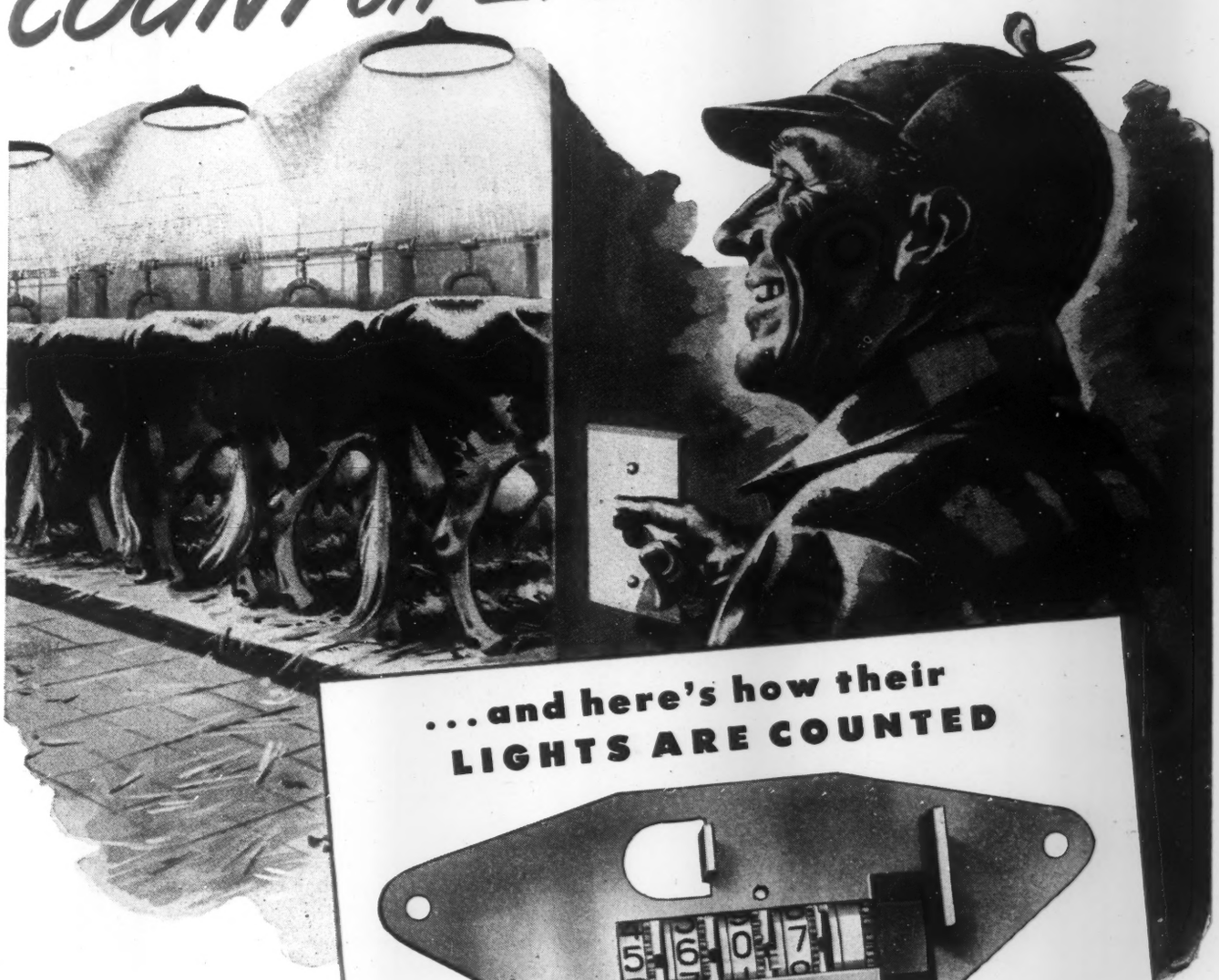
AMERICAN BLOWER CORP., DETROIT 32, MICH.
In Canada: CANADIAN SIROCCO CO., LTD., Windsor, Ont.

Division of American Radiator & Standard Sanitary corporation

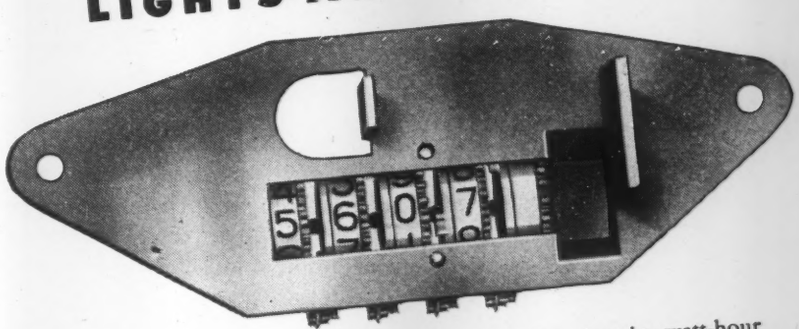
* ***Gýrol Fluid Drive*** *is a fluid power transmission pioneered and developed for American industry by American Blower. It is used wherever smooth transmission of power or adjustable speed control is desired. Looking beyond the long list of applications already developed, we will gladly work with you to find new ways to "Fluid-Drive Ahead!"*

NOW... THOUSANDS OF FARMERS CAN ALWAYS

COUNT on LIGHTS



...and here's how their LIGHTS ARE COUNTED



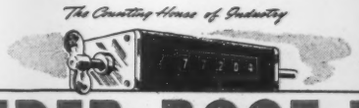
Veeder-Root Watt-Hour Counter, built into electric watt-hour meters. This counting device gives the farmer direct reading of current consumption in number of watt-hours.

Lanternlight for chores always appealed to poets — but not to practical farmers. And now, in certain sections of the country, the instant command of adequate electricity has lightened the farmer's work in more ways than one . . . and put an end to a dread fire-hazard, too.

Extended to farmers in outlying districts, the comfort, safety and greater work-capacity of electric light and power have had a whole lot to do with today's amazing farm productivity.

And the whole deal, for the farmer, is as simple as this: Once a month he takes a *direct reading* from his electric meter, notes the reading on a postcard, mails the card, soon gets a bill. And what he reads is the Veeder-Root Watt-Hour Counter, built into the large meter as an integral part. This is another instance of the infinite ways in which Veeder-Root *Count*rol can be designed into any type of product as an added advantage in use. More than likely, Veeder-Root *Count*rol can be designed into your product . . . in the form of a standard counter, or one developed specially for your particular need. It's well worth finding out — and *you can count on that!*

The Counting House of Industry



VEEDER-ROOT INC.

Hartford 2, Connecticut

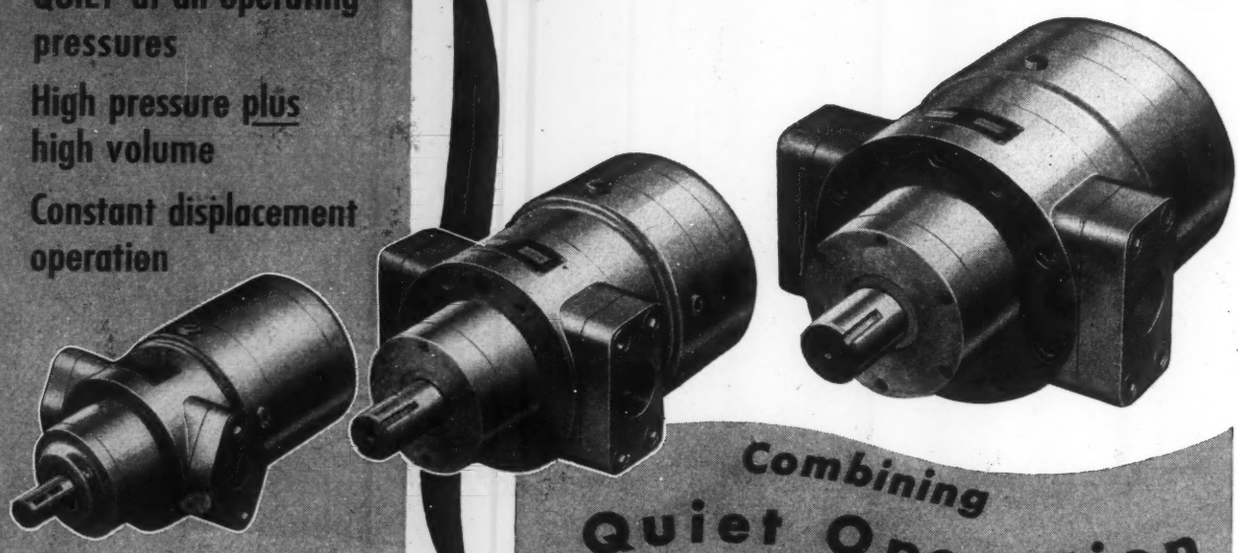
In Canada: Veeder-Root of Canada, Ltd., 955 St. James St., Montreal 3.
In England: Veeder-Root Ltd., Dickinson Works, 20 Purley Way, Croydon, Surrey.

DENISON 3500 SERIES Hydraulic Pumps

QUIET at all operating pressures

High pressure plus high volume

Constant displacement operation



Combining
Quiet Operation
High Pressure
High Volume

Fewer parts—extremely compact

ALL thrust bearings eliminated

Unique two-piece shaft absorbs deflection . . . reduces bearing wear

Axial piston design lengthens service

Pressure-balanced piston shoe—no direct contact between shoe and cam plate

Now you can have hydraulic pumps that combine *speed* with *power* in a degree never before attained . . . pumps that operate *quietly* throughout their entire speed range . . . pumps so greatly simplified in construction and operation that they bring a new conception of long service-life and low maintenance cost.

Exclusive design of these axial piston, constant-displacement pumps provides high-volume delivery at all operating pressures. Actual tests prove that they will operate continuously at 1200 rpm, delivering pressures of 3500 psi with volumetric efficiencies of 95% *or more.*

Among the many outstanding features built into these unique hydraulic pumps is a newly developed pressure-equalization principle, which eliminates the "scream" or noise produced by ordinary hydraulic pumps. They're amazingly quiet at *all* pressures.

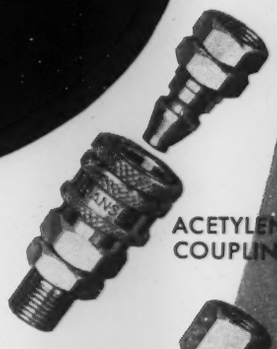
Denison HydrOILic Pumps in this 3500 series are available in three models, delivering volumes of 6, 17, and 32 gpm. Write for complete details.

HydrOILics INDUSTRY'S RIGHT HAND

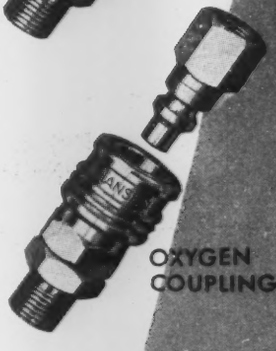
THE DENISON ENGINEERING COMPANY
1156 DUBLIN RD., COLUMBUS 16, OHIO

DENISON EQUIPMENT in APPLIED HydrOILics

HANSEN *Couplings*
Are Used On a VARIETY of JOBS



ACETYLENE COUPLING



OXYGEN COUPLING

EACH DAY a new use is found for Hansen couplings, proving their adaptability, versatility and right design. Hansen couplings have made their mark in many fields and their long list of accomplishments is growing longer each day.

There is a specific Hansen coupling made for air, oil, grease, oxygen, and acetylene, and they come in a wide range of standard sizes.

Hansen couplings are simple and easy to operate — merely push plug into socket, coupling is connected and locked — slide sleeve back with thumb, coupling is unlocked and disconnected. Hansen couplings are rugged, with all moving parts fully protected, consequently they will stand up under rough usage. Complete swivel action prevents kinking of hose. They can be readily incorporated in new or existing equipment.

Our representatives will be glad to discuss with your engineers the possibilities and many advantages of Hansen couplings. Send for illustrated catalog.

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Ever LOCK WASHERS

MANY WIDE CHISEL EDGES

POWERFUL SPRING TENSION

The effectiveness of EverLOCK *double* gripping action—wide chisel edges teamed up with balanced spring tension—make EverLOCK Washers first choice wherever *positive* locking action is vital.

EverLOCK Washers are equally outstanding in holding down production costs. A half turn or less gives a positive lock—saving time and labor—avoiding all hazards of stretched bolts and distortion of threaded parts. Four standard types meet most lock washer needs.

Your inquiries are invited.

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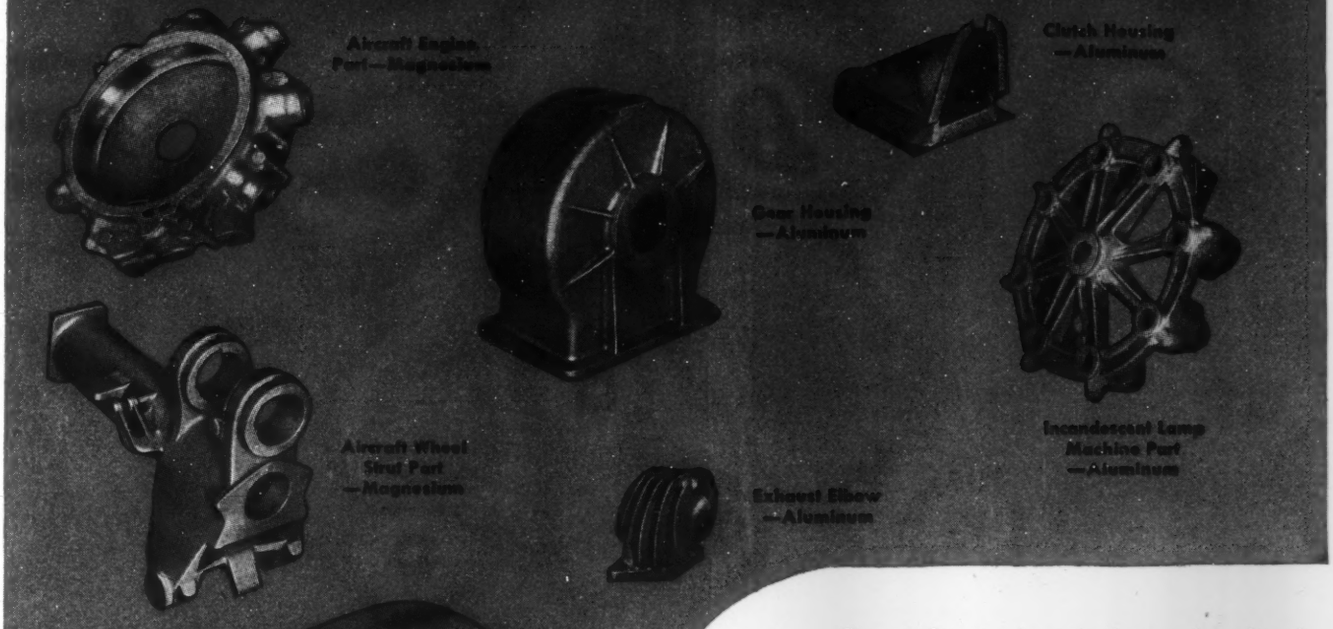
for ALUMINUM, MAGNESIUM AND BRONZE
SAND CASTINGS



Our 36 years' experience in aluminum and 15 years' experience in magnesium may enable us to shorten the time (perhaps even by several months) from blue prints to production of your new or re-designed products.

In addition to this background in light metals, we have had long experience in making patterns—both wood and metal. As you know, it is especially desirable to have patterns for magnesium parts made in the same plant that produces the castings. . . . Send us your blueprints for quotation or we shall be glad to have a field representative call to discuss your castings and pattern requirements.

Patterns in Metal and Wood
"WELLMAN *means* WELL-CAST"

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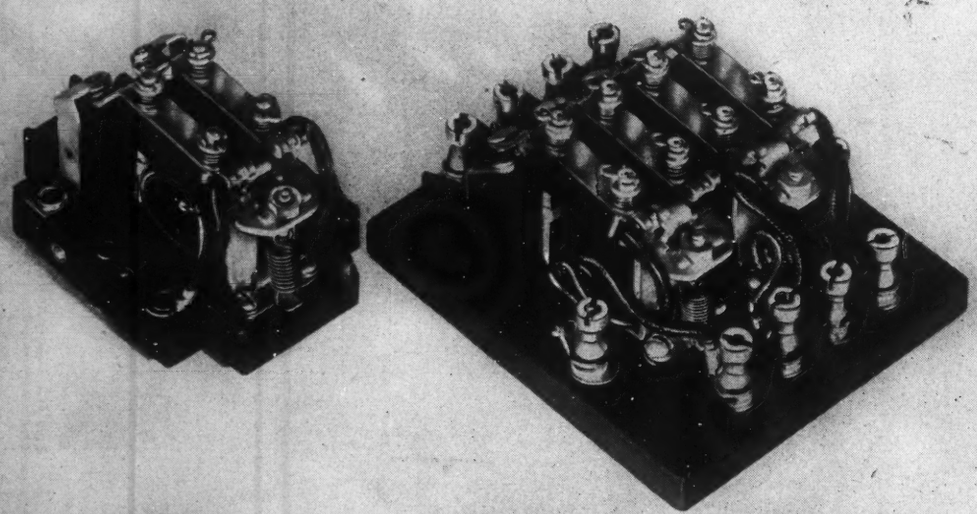
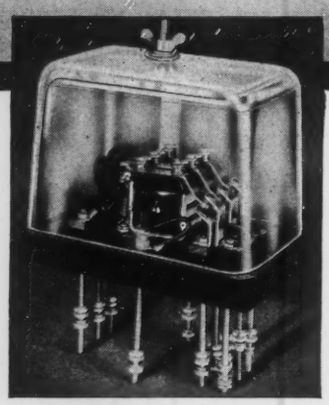
Midget Relays





Glass enclosed type for switchboard mounting

SMALLEST SIZES CONSISTENT WITH DEPENDABLE OPERATION

• Designed for long, trouble-free performance wherever space, weight or moderate cost are important considerations. Available for a.c. or d.c. use as specified. *Exceptionally quiet on a.c. applications.* Conservative contact ratings (based on heater load values) are:

6 amps. at 115 volts a.c.
3 amps. at 230 volts a.c.
0.5 amp. at 115 volts d.c.

• Underwriters' approved. Individually tested. Ideally suited for built-in applications, control of small motors, heaters, audible and visual signals, lamp control and various other uses. Special adaptations available for radio-frequency, low-voltage loads, audio-frequency loads and other exacting uses.

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5,327 RELAY TYPES

STRUTHERS-DUNN, Inc., 1321 Arch St., Phila. 7, Pa.

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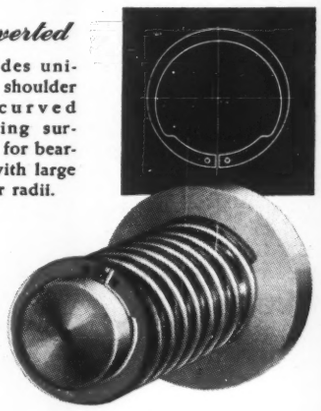
Precision fastening for any need: Waldes Truarc Special-Type Retaining Rings

Inverted

Provides uniform shoulder for curved abutting surfaces, for bearings with large corner radii.



Beveled & Bowed

Takes up end-play rigidly or resiliently, accommodates accumulated tolerances.

Self-Locking

Economical where thrust is moderate — holds fast, yet shaft requires no machining.

Interlocking

2-piece ring takes heavy thrusts, gives positive lock, secure against high RPMs.

*Crescent**

Snaps on radially where axial assembly is impossible. No special tools needed.

E-Ring

Variant of Crescent for small shafts; provides large, strong shoulder. Easily removed.

There's a Waldes Truarc precision-engineered ring to answer every need. Truarc Retaining Rings give a never-failing grip because of their mathematically precise construction. No matter how demanding your specifications, it's a simple matter to refine your present designs to save material, machining and assembly costs. Waldes Truarc engineers will help you, will give your particular problem individual attention without obligation.

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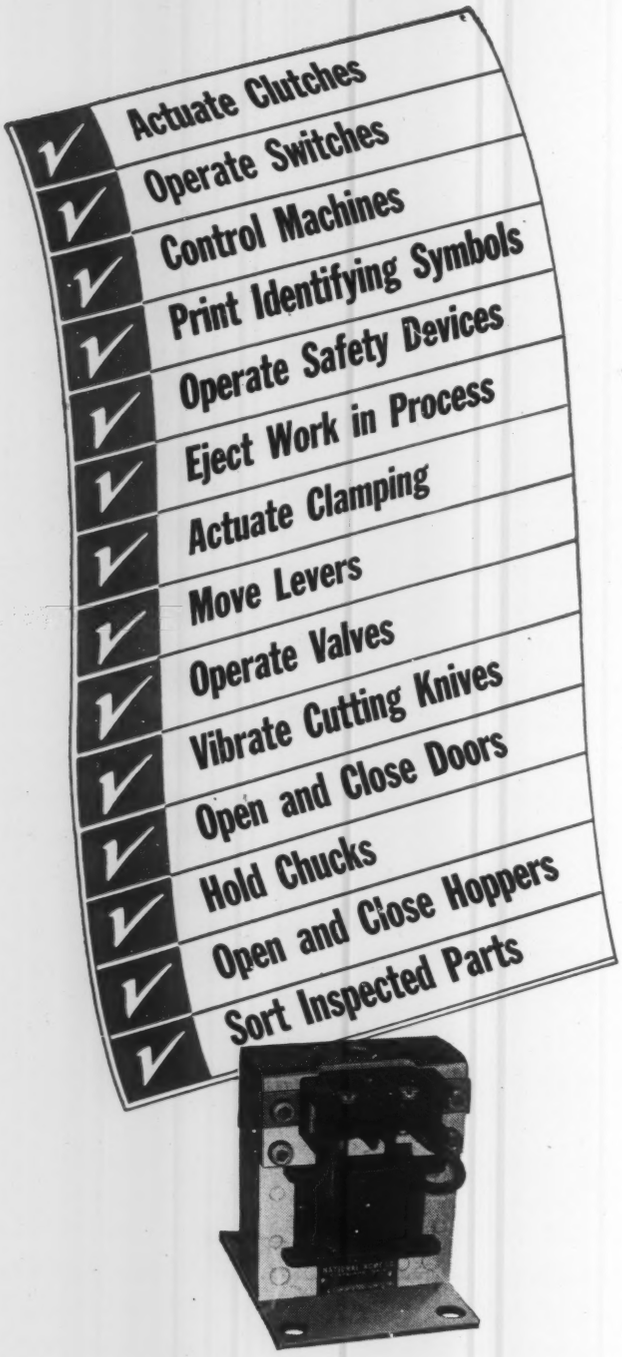

Namco "Stellite"—welded Solenoids are built in sizes with ratings from 2½ to 25 pounds, push or pull, at 1″ stroke. Combination push-pull and other special applications are available. For alternating current only, constant or intermittent duty.

If you have jobs like these... then you need SOLENOIDS

They're the modern, up-to-date way of doing jobs automatically—by remote control, and in cramped quarters if necessary.

With the positive, accurate action of Solenoids you can simplify design, manufacture and operation. They're taking the place of expensive, bulky gear trains, levers, linkages and other mechanisms. Many a manufacturer has come to us with a cost or space problem—and has found the solution in Namco Solenoids.

Namco Solenoids—with "Stellite"—welded contacts, are compact, rugged and reliable. They're *engineered* to the requirements of the job, with the aid of an *expert*. That's where we can help you. We'll be glad to recommend the size and style best suited to your job—with standard or special terminal blocks and mountings. Like more details? Ask for bulletin EM-46.

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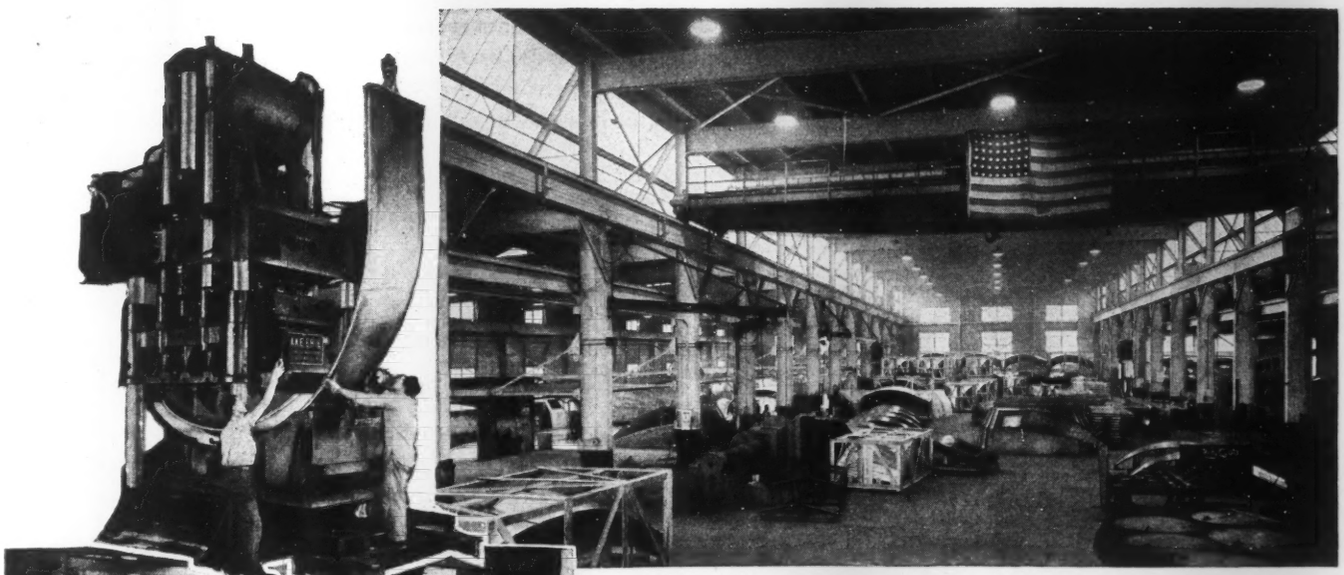

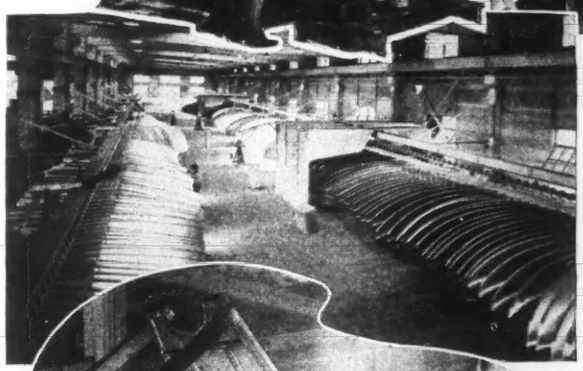

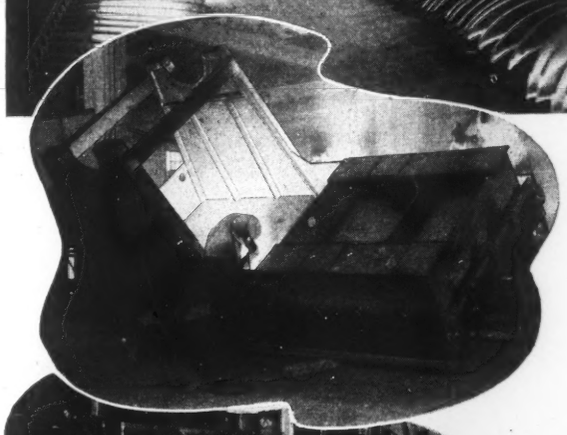

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SPECIALIZED
MASS PRODUCTION METAL WORK

Under one roof, Brandt offers you 150,000 sq. ft. of metal working facilities, streamlined for mass production of "out-of-the-run-of-mine" jobs.

STAMPINGS **FORMING**
HEAVY WELDMENTS

Spot Welded Assemblies **Plate Fabrication**
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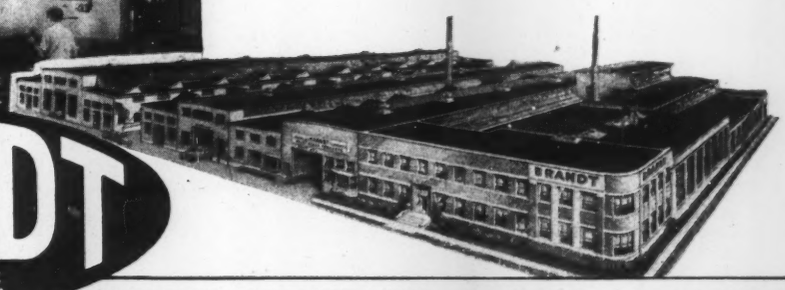
MILD STEEL **STAINLESS STEEL**
ARMOR PLATE
SHEET METAL
ALUMINUM **MAGNESIUM**
NON-FERROUS METALS

Proximity to steel mills and to both rail and water transportation assures prompt delivery. If you have a Specialized metal production problem . . . Call BRANDT.



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BRANDT
BALTIMORE

CHARLES T. BRANDT, INC., 1700 RIDGELY ST., BALTIMORE-30, MD.

Precision METAL CRAFTSMEN SINCE 1890 ★ ★ ★ ★

"Impossible" is a word that is not recognized by engineers. To dam a mighty river, tunnel under it or suspend a bridge across it—things such as these that once seemed pure imagination were made possible by instruments devised to refine and extend human faculties, to translate the precision of engineering thought into action.

Keuffel & Esser Co. is proud to have played so large a part in making such instruments widely available. In this way K & E equipment and materials have been partners of the engineer and draftsman for 78 years in shaping the modern world. So universally is this equipment used, it is self-evident that K & E have played a part in the completion of nearly every engineering project of any magnitude. Could you wish any surer guidance than this in the selection of your own "partners in creating"?

Not only for construction and building, but for setting up precision machine tools and long production lines, in the fabrication of large ships and aircraft, experienced engineers know that they can rely utterly on K & E transits and levels. Coated lenses for increased light transmission, precision-ground adjusting screws, chromium-coated inner center and draw tubes, completely enclosed leveling screws, improved achromatic telescopes—all these typify the advanced design of these instruments.

partners in creating

Skilled craftsmen of the Orient forged the famous Damascus swords from about the tenth to the fifteenth centuries. Tradition relates that these famous swords were laboriously hammered at the forge until the metal resembled the color of the moon, when the blade was quenched by driving it into the side of a slave. Then, as now, each group of forging craftsmen jealously guarded a standard of quality. Differences in the quality of forgings were inevitable, and the differences were due then, as they are today, to pioneering, ingenuity and enterprise—to the irrepressible urge to excel in forging craftsmanship.

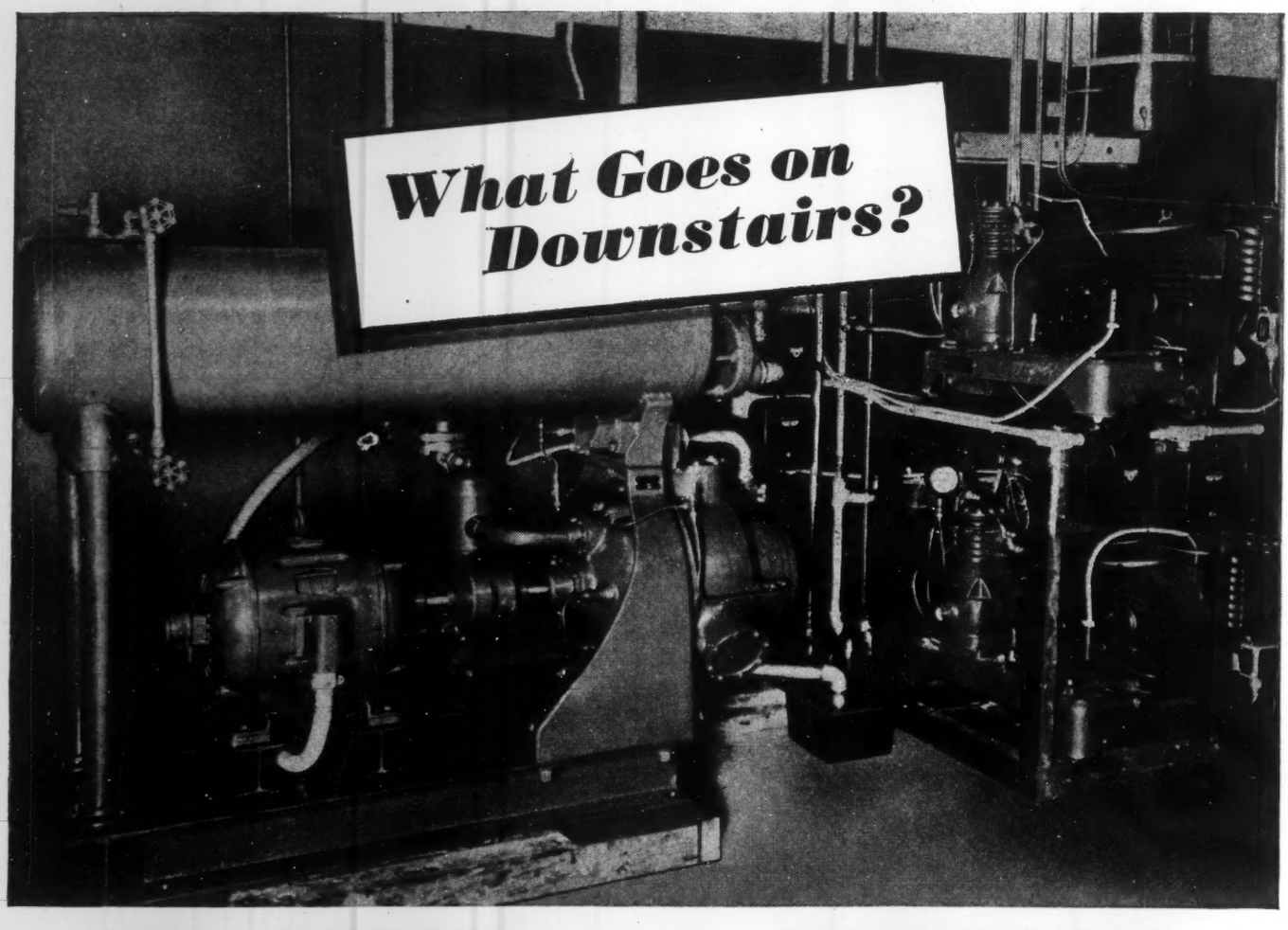
X The Vital Element in the Improvement of Metals by Forging is..MEN!

Differences in the quality of forgings as between two or more sources of supply are inevitable. Differences in tolerances are visible and measurable, but differences of vital importance are revealed only by microscopic or X-ray examination. Differences in the mechanical properties of forgings are the result of individualized applications of engineering principles and forging techniques, applications which differ in accordance with the difference in the skill and philosophy of executives, engineers, metallurgists and forging craftsmen. Fortified by 33 years' experience in forging intricate designs, and by specialized metallurgical and engineering skill thus acquired, Steel Improvement Forging Engineers and Metallurgists: (1) know the exact forging technique that should be utilized for developing fully the qualities, inherent in a specific grade of steel, that are required to meet the stresses occurring in a specific service condition; (2) advise and assist designers regarding the correct placement of parting lines and other design elements; and (3) adhere strictly to a policy of projecting a promise of quality and delivery only when such promise can be substantiated by fact or experience, or both. Consult a Steel Improvement Forging Engineer about the measure of quality in forgings you require.

Write for reference booklet titled "The Improvement of Metals by Forgir g", which has been prep. red especially for executive engineers, designers and metallurgists. .

DROP
THE STEEL IMPROVEMENT & FORGE CO.
FORGINGS
954 East 64th Street CLEVELAND, OHIO
SALES OFFICES: NEW YORK • CHICAGO • MILWAUKEE • TULSA • LOS ANGELES

DROP, UPSET AND PRESS FORGINGS FROM A FEW OUNCES TO 500 LBS. OF ALL FORGEABLE METALS

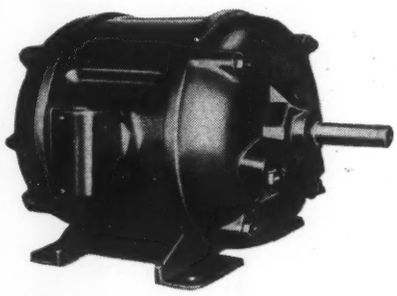


WAGNER *Quality* MOTORS

help customers shop in cool comfort . . .

Busy shoppers never give a thought to what goes on downstairs. They're not interested in motors that drive the apparatus responsible for their comfort. But smart merchandisers know that comfort quickly turns prospects into customers. They know, too, that the dependability of the motors that drive air conditioning, heating, and ventilating equipment is of paramount importance. That's why you find hundreds of thousands of Wagner Quality Motors on the job everywhere driving all types of apparatus that help customers shop in comfort.

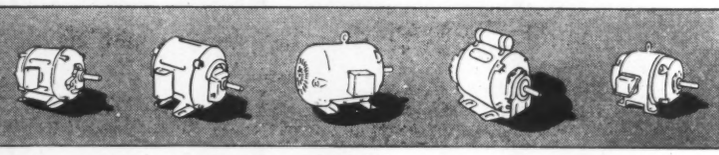
Today, hundreds of equipment manufacturers have standardized on these outstanding Wagner Quality Motors. Wagner can help you, too. If you manufacture or use motor-driven equipment, it will pay you to investigate Wagner Motors. Users of Wagner motors also profit by our quick, convenient, nation-wide service facilities. Twenty-nine branch offices, located in principal cities, are ready to give you service and advice. Contact our nearest office, or write Wagner Electric Corporation, 6404 Plymouth Ave., St. Louis 14, Mo., for bulletins on the complete line.



The motor illustrated above is typical of the Wagner complete line of polyphase and single-phase motors.

Wagner Electric Corporation
EST. 1891

Consult Wagner Engineers on all Electric Motor Problems



M47-4

• ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES • AUTOMOTIVE PRODUCTS •

Design engineers in industry were faced with the need for a bellows with extra strength for service far in excess of normal limits.

Standard metal bellows, ideal for most pressures, just couldn't stand the gaff.

Fulton Sylphon application engineers, working closely with these customers, developed a product now wide and favorably known as the Sylphon Multi-ply bellows.

Multi-ply bellows consist of two, three and four metal tubes fitted closely together and then corrugated as a unit—just as standard bellows are corrugated. The result is extra strength . . . sufficient to withstand high pressures . . . without excessive loss of flexibility.

Precision built by specialists with more than 45 years' experience, these rugged multi-ply bellows . . . like all Fulton Sylphon products . . . are engineered to do their job better, longer, at less cost to you.

Why not find out today how they can be used profitably in your business? Catalog AK-1300, packed full of information and idea starters, is yours for the asking.

FS

FIRST WITH BELLOWS

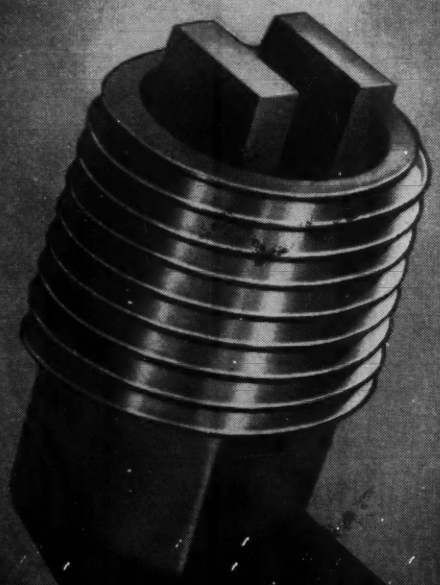
THE FULTON SYLPHON CO. KNOXVILLE 4, TENN.

FULTON SYLPHON

Temperature Controls • Bellows • Bellows Assemblies

Canadian Representatives, Darling Brothers, Montreal

what a BIG difference a little Magnet makes



It's the Magnet that Protects Your Product

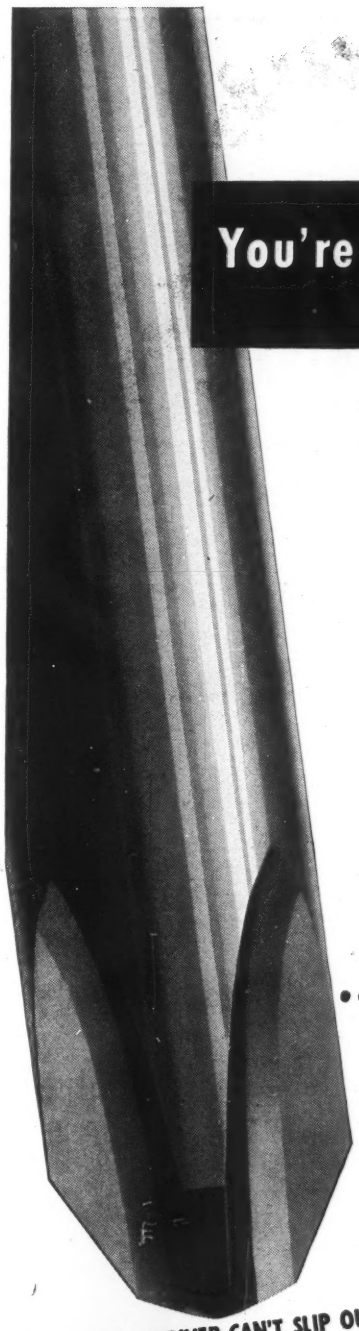
The powerful, permanent magnet in the Lisle Magnetic Plug attracts and holds iron and steel particles which wear off moving parts and circulate in the lubricant. Removal of this abrasive metal cuts down wear; reduces oxidation of the oil; substantially increases the life of costly bearings and gears. Specify Lisle Plugs in place of ordinary drain plugs. Write for Free Magnetic Plugs to test in your product.

Lisle Magnetic PLUGS

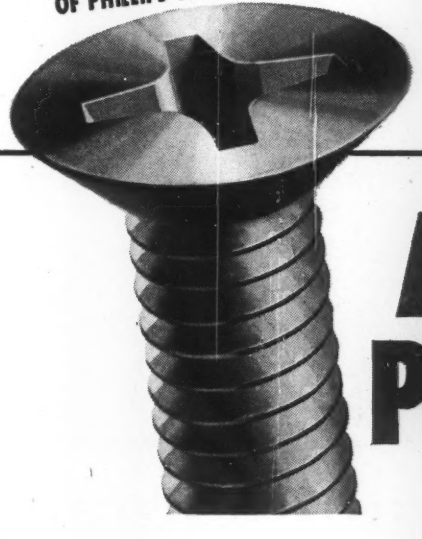
Manufactured by LISLE CORPORATION
Box 1003 Clarinda, Iowa

You're Cooking on Both Front Burners

(PRODUCTION AND SALES, TOO)



4-WINGED DRIVER CAN'T SLIP OUT OF PHILLIPS TAPERED RECESS



...when you use AMERICAN PHILLIPS SCREWS

IN PRODUCTION: Many top-rank stove builders and other makers of household appliances rate the modern method of American Phillips Screw-driving as a major means of cost-control. For American Phillips Screws save by making power-driving practical on *all* jobs. And they save in many other ways: Fumble-proof starts, automatically straight driving, no burred screwheads or spoiled work, faster assembly . . . and more finished goods on the shipping platform *every day. Sum of all time-savings runs as high as 50%.*

IN SALES PROMOTION: American Phillips Screws give *any* product a smartly finished, modern look that packs plenty of appeal to purchasers. And there are no snags to catch hose or clothes. So American Phillips Screws pay off double...in the plant and on the sales-floor. Ask American to show you how and why *American Phillips Screws always cost least to use.*

AMERICAN SCREW COMPANY, PROVIDENCE 1, RHODE ISLAND

Chicago 11: 589 E. Illinois Street *Detroit 2:* 502 Stephenson Building

AMERICAN PHILLIPS *Screws*

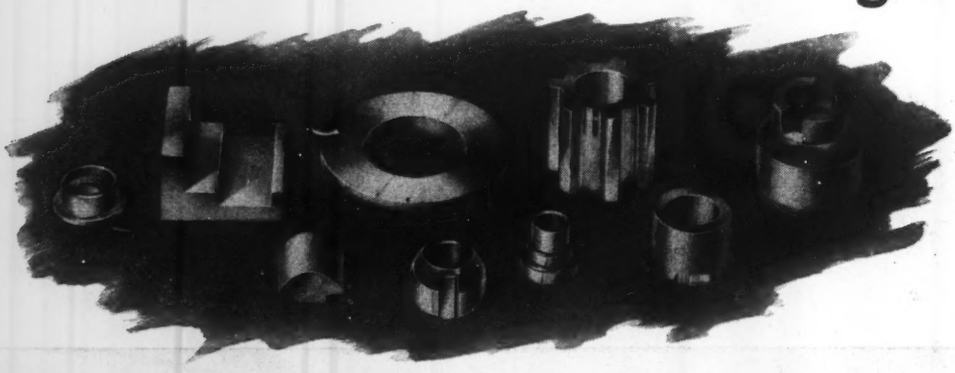
ALL TYPES

ALL METALS: Steel, Brass, Bronze, Stainless Steel, Aluminum, Monel, Everdur (silicon bronze)

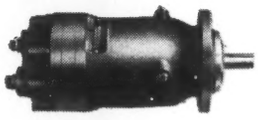
Redesigning of bearing saves customer 50%

Our engineers are constantly at work to add further economies to those already effected through the use of Gramix self-lubricating powder metal parts. For example, we recently saved one manufacturer $1500 on 100,000 bearings by the simple expedient of reducing the wall thickness on a small cylindrical bearing, and the redesigned bearings after exhaustive tests have proven to be as efficient and dependable as the previous type. Gramix parts are tough, durable and because of their controlled porosity permit impregnation with lubricant which renders further lubricant unnecessary. We will be glad to show you how Gramix powder metal bearings, thrust washers and structural parts, die-pressed to extremely close tolerances and with perfect bearing and sliding surfaces, may enable you to turn out better products for less money. Send us drawings or descriptions of your products so our engineers may make specific recommendations.

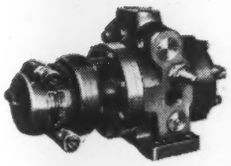
gramix



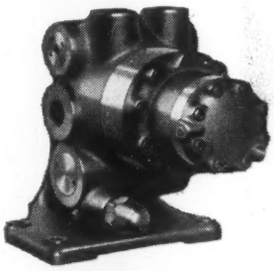
THE UNITED STATES GRAPHITE COMPANY • SAGINAW, MICHIGAN



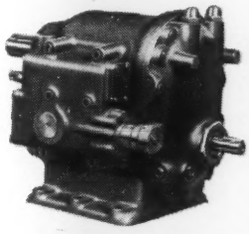
FLUID MOTORS



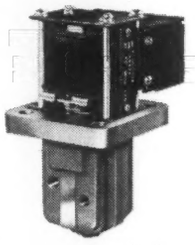
PUMPS



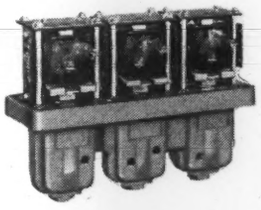
CLAMPING PUMPS



TRANSMISSIONS

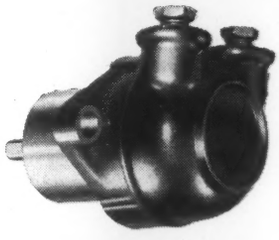


SINGLE SOLENOID VALVES



THREE-WAY SOLENOID VALVES

FOUR-WAY VALVES



LUBRICATING PUMPS

FREE DATA

is included in this series of up-to-date bulletins. Write for your copies today. Ask for bulletins No. M-13.

● These standard elements are designed to function smoothly in any circuit combination. Consequently, when you obtain a complete Sundstrand hydraulic circuit, you'll get smooth, fast-acting equipment.

Regardless of the type of machine you are designing, if you have movements to control, you'll do it better, faster and cheaper *hydraulically*.

Look into the features of tested Sundstrand hydraulic equipment. One of our application engineers will be glad to assist in the design of a circuit to meet your specific requirements. There is no obligation for this service.

SUNDSTRAND PUMP DIVISION

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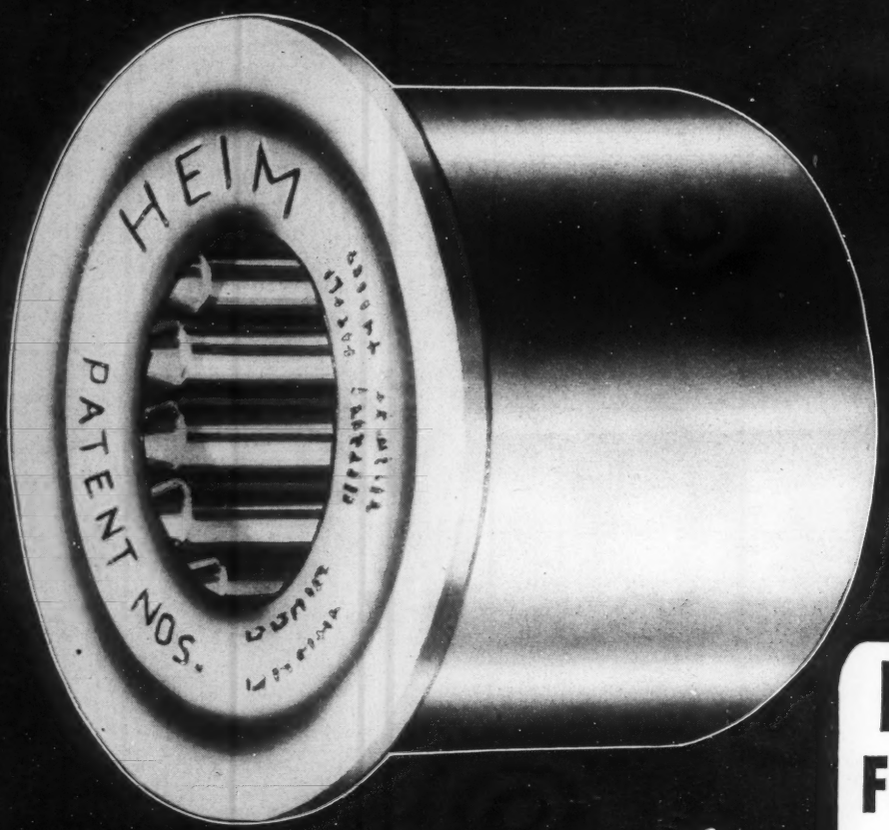
FUEL UNITS • HYDRAULIC PUMPS • TRANSMISSIONS • FLUID MOTORS • VALVES and CONTROLS



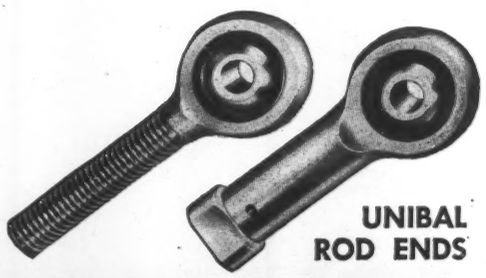
Self Contained

HEIM FLANGED TYPE ROLLER BEARING

The Heim Flanged Type Self Contained Roller Bearing is inexpensive and extremely simple to mount. It is only necessary to bore and ream the hole and press the bearing in. No shoulder needed against which to locate. Flange provides means for taking axial thrusts or shocks. Designed to retain lubrication and exclude dirt and foreign matter. Made in two types — light duty for use where r.p.m. is low and loads light; and a heavy duty, heat treated bearing for heavy loads.

PROMPT DELIVERY ON STANDARD SIZES

HEIM ALSO MAKES . . .
UNIBAL SPHERICAL BEARINGS • SPHERICAL BEARING ROD ENDS • DIE POLISHING MACHINES.



UNIBAL ROD ENDS

THE HEIM COMPANY
FAIRFIELD CONNECTICUT

PLUS Sales Value for Good Tools— Drop Cords Jacketed in

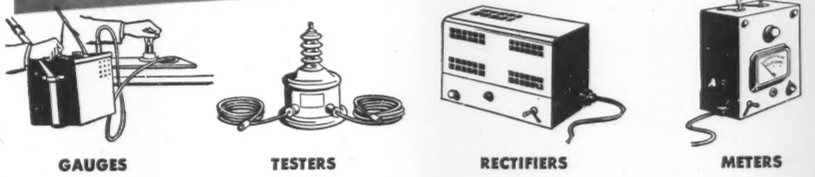
TOUGH, DURABLE NEOPRENE

A Top-Quality Drop Cord for Your Top-Quality Products

TOOLS

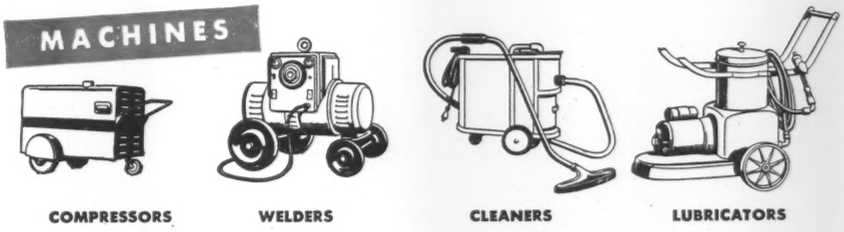
DRILLS TAPPERS SANDERS BLOWERS

INSTRUMENTS



GAUGES TESTERS RECTIFIERS METERS

MACHINES



COMPRESSORS WELDERS CLEANERS LUBRICATORS

A WELL-ENGINEERED tool deserves a good drop cord. It conforms to the quality of design and construction of the tool. It gives an added plus value which your Sales Department will thank you for when it is translated into repeat orders.

These are the qualities which result in longer drop cord life for a neoprene jacketed cord. Neoprene resists sunlight, wear, tearing, crushing, oil, and heat. For quality tools specify a quality cord with a neoprene jacket.

Here's Why Neoprene DOES SO MANY JOBS SO WELL!

- ★ High tensile strength, resilience, low permanent distortion.
- ★ Tough and durable, resists abrasion and cutting.
- ★ Superior resistance to sunlight, aging, ozone, and heat.
- ★ Resistance to deterioration by oils, solvents, chemicals, acids.
- ★ Superior air-retention, low permeability to gases and fluids.
- ★ Special compositions are flame-retarding, static-conducting, flexible at low temperatures.

Write for *your free subscription to The Neoprene Notebook. Packed with information about new or unusual neoprene applications —which may give you valuable new ideas. Back issues on request. Rubber Chemicals Division A-1, E. I. du Pont de Nemours & Co. (Inc.), Wilmington 98, Delaware.*

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The* VERSATILE *Synthetic Rubber

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. . . THROUGH CHEMISTRY

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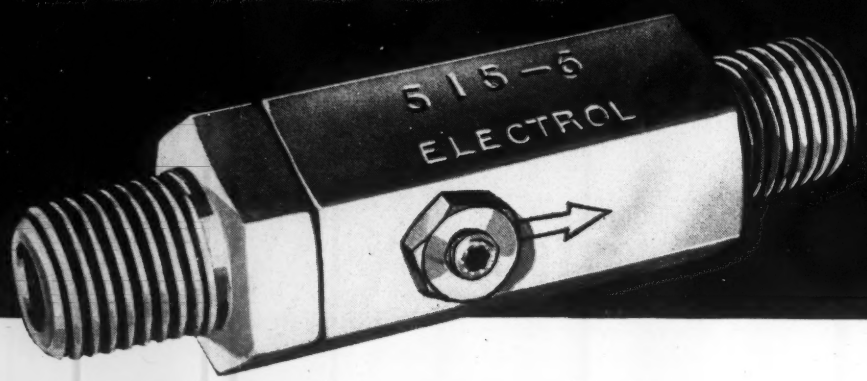
ELECTROL'S



NEW AND BETTER SPEED CONTROL VALVE

This *new* addition to ELECTROL'S check valves permits free flow in one direction and — by use of a new metering device — provides precisely controlled, variable flow in the opposite direction. This flow is controlled to meet individual requirements by the adjustment of a screw-actuated metering pin set in one side of the valve.

This *new* valve is compact and can be used with pressures up to 1,500 P.S.I. — higher if desired. It handles air as well as oil at high — *and* extremely low — pressures.

Made with ⅛, ¼, ⅜ and ½ inch NPT port sizes. Other sizes to order.

Write today for detailed information covering your requirements.

ELECTROL *INCORPORATED*

FOR BETTER HYDRAULIC DEVICES

KINGSTON, NEW YORK

CYLINDERS • SELECTOR VALVES • FOLLOW-UP VALVES • CHECK VALVES

RELIEF VALVES • HAND PUMPS • POWERPAKS • OLEO STRUTS • SOLENOID VALVES

ON-OFF VALVES • SERVO CYLINDERS • TRANSFER VALVES • CUT-OUT VALVES

Measuring muscle by electronics

Frank Kanera
J & H Associate, Plant No. 7

Extra values through

JACK & HEINTZ

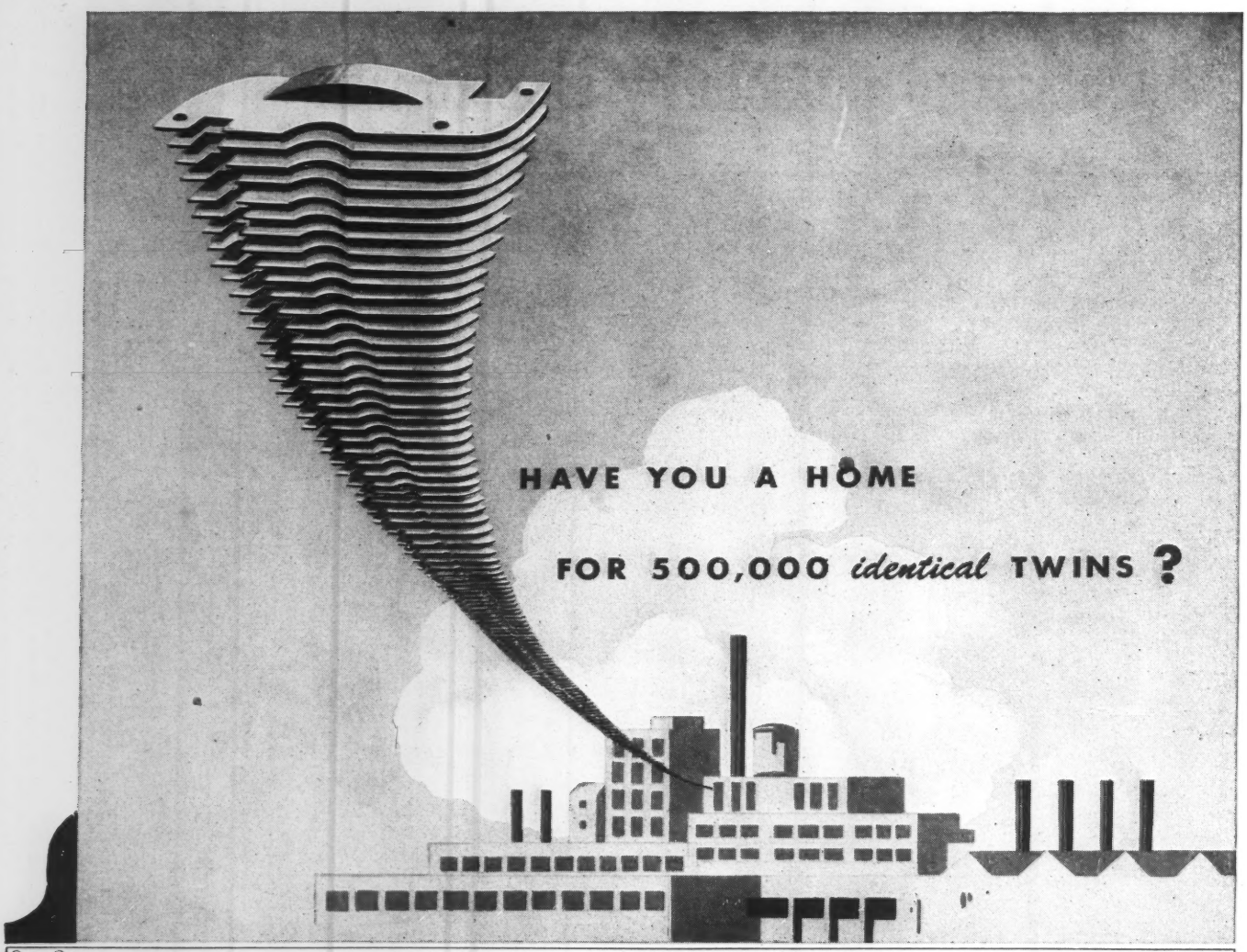
Mass Precision

The usual way to measure the torque of electric motors is to use an apparatus of wheels, brakes and weighing scales. This method was too slow and cumbersome for the new Jack & Heintz Fractional Horsepower Motor Plant.

So Jack & Heintz Production Engineers developed an ingenious electronic dynamometer which measures motor torques *in a few seconds* with unheard-of precision. An operator simply plugs in the motor and reads the torque on a dial. This helps speed up the production of Jack & Heintz motors for urgently needed appliances.

This is typical of the achievements of Jack & Heintz *mass precision* which are producing extra values in motors, refrigeration compressors, aircraft accessories, Eisemann magnetos and bearings *today*, and which promise startling developments for *tomorrow*.

JACK & HEINTZ PRECISION INDUSTRIES, INC., *Cleveland 1, Ohio*



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TOOLS AND DIES
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SPECIAL MACHINERY

By "Home", we mean your manufacturing plant. By "Twins", we refer to Metal Stampings, and "Identical" is the exactness of repetitive production . . . the quality of Stampings produced in quantity by Atlas from accurate Atlas-made dies.

Our bid for your business is based on our belief that too many stampings, too low in quality, are bought by too many plants. Yet if you make your own for controlled accuracy, your costs usually advance because of Stamping Press down-time.

We have few idle presses at Atlas. Small and medium size stamping jobs in never-ending variety proceed in orderly manner from blueprints to dies to production . . . and final finishes if desired . . . at costs few plants can approach.

For better dies, better stampings, fast production . . . and prices that help give you a competitive advantage . . . check with Atlas. Complete details on request.

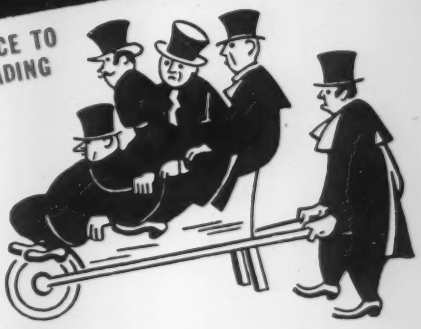
ATLAS METAL STAMPING COMPANY
CASTOR AND KENSINGTON AVES., PHILADELPHIA 24, PA.

The Swing is to Fiberglas High-Safety-Factor Insulation

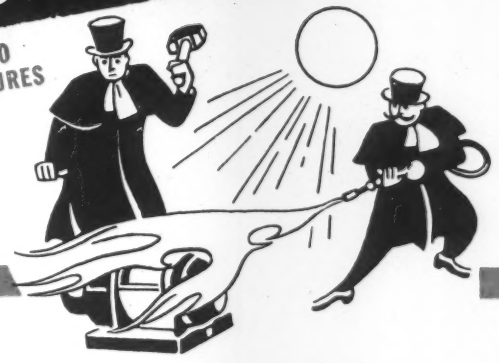
RESISTANCE TO EXCESSIVE MOISTURE

RESISTANCE TO DIRT, DUST AND CORROSIVE ACIDS

Give your products these 5 advantages



RESISTANCE TO OVERLOADING



RESISTANCE TO HIGH TEMPERATURES

You not only get mechanical and electrical advantages by using Fiberglas Electrical Insulation Materials—advantages such as resistance to heat, moisture, oils and acids, and stamina to withstand overload—but you also impart to your product that 5th important element—SALES ADVANTAGE.

Fiberglas Electrical Insulations have won the preference of thousands of men who design, build and use electrical equipment, by doing a good job on tough assignments throughout industry. Acceptance is growing every day as the unusual combination of characteristics that only Fiberglas can offer becomes known.

Available for almost every electrical insulation need, Fiberglas products have made smaller, lighter and more dependable electrical equipment possible. Have you taken full advantage of Fiberglas in solving your company's production and sales problems? Send for catalog EL 46-11 or the folder "What's a Sales Advantage Worth?" If your distributor does not carry Fiberglas, ask for the name of the Fiberglas supplier located nearest to you. Owens-Corning Fiberglas Corporation, Dept. 808, Toledo 1, Ohio. Branches in principal cities.

In Canada: Fiberglas Canada Ltd., Toronto, Ontario.

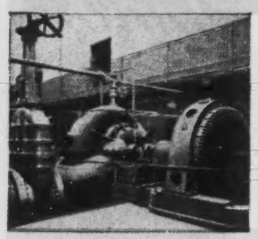
OWENS-CORNING
FIBERGLAS

Fiberglas is the trade name for these electrical insulation materials and many other products made from fine, strong, pliable, moisture- and heat-resistant, ageless glass fibers.

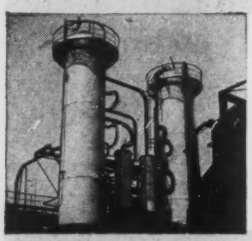
INDUSTRY BANS RUST AND CORROSION *with* EVERLASTING FASTENINGS

Few industries can escape the destructive effects of rust and corrosion but *all* industries can reduce their costly ravages in maintenance and breakdown. Here are five industrial applications where Harper's EVERLASTING FASTENINGS have licked rust and corrosion.

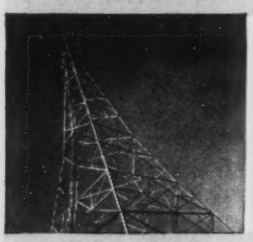
MONEL STOPS CORROSIVE CHEMICALS Problems in salt production have been solved by using Monel bolts. In mining, treating and handling of many chemicals, non-ferrous alloys are the answer to efficient operation.



BRASS GUARDS WATER SYSTEMS In valves and pumps that compose the heart of water works, Brass fastenings help in eliminating the most common cause of replacement—rust.



STAINLESS STEEL SOLVES OIL PROBLEMS Acids and gases at high temperatures attack metal but Stainless Steel alloys cut refinery replacements to a minimum, assure years of continued operation.



UTILITIES CHOOSE SILICON BRONZE Weather is the bug-a-boo in power lines and other utility applications. Silicon Bronze Bolts reduce season "cracking" and maintenance costs.

NAVAL BRONZE WINS ON THE SEA Marine applications demand high strength plus resistance to salt air and water. Naval Bronze fastenings have proved their dependability in marine diesels and ship fittings.

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Call upon Harper to solve fastening problems in *your* industry

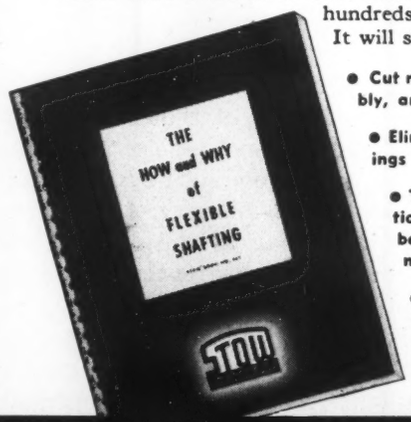
POWER TRANSMISSION from almost any angle!

WITH

STOW FLEXIBLE SHAFTING

This portable, Payne Dean valve-operating mechanism is shown attached to a floor stand for raising and lowering large gates. With a STOW Flexible Shaft eliminating gears, bearings, and universals, there can be any number of variations between centre lines of driving and driven members, or even constantly changing distances—*while operation is under way!*

Learn more about the principle of STOW Flexible Shafting and what it can do for you. Write for a FREE copy of THE HOW AND WHY OF FLEXIBLE SHAFTING, the book that contains the solution to hundreds of design problems. It will show you how to—



- Cut manufacturing, assembly, and servicing costs.
- Eliminate gears, bearings and universal joints.
- Transmit rotary motion around angles and between out-of-line members.
- Make your product more competitive—simpler, smoother, smarter.

STOW MANUFACTURING CO.
11 Shear St. Binghamton, N. Y.

Scovill

NON-FERROUS

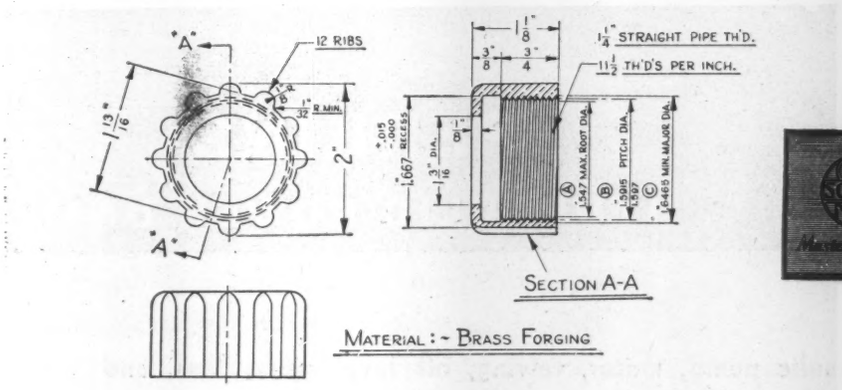
FORGINGS

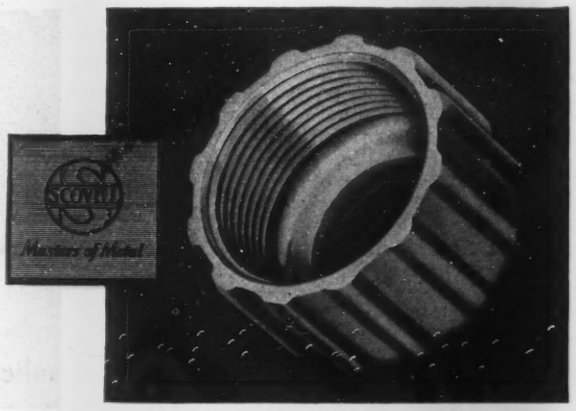
When SCOVILL becomes your METAL-PARTner . . .

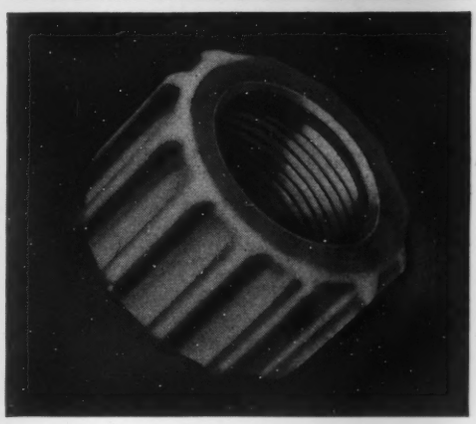
MACHINED FORGINGS AT LOWER COST THAN BY PRESENT PRODUCTION METHODS MAY BE POSSIBLE

Originally, this brass packing nut was a screw machine item, requiring 1168 lbs. of special shape rod per thousand pieces. By changing to forging, Scovill cut down the amount of metal to 619 lbs. per thousand — a two-way saving, because of the lower cost of the forging rod.

But Scovill economy is concerned not only with savings in materials. Our modern machining equipment also saves time in the production of forgings. The net over-all saving in this particular case was about 75 per cent.





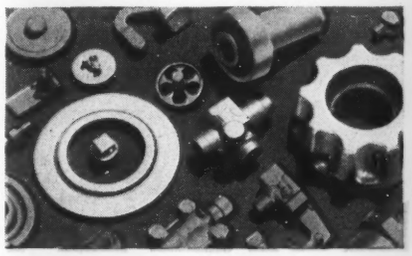


Are you completely satisfied with the brass, aluminum or other non-ferrous metal parts you're now using? If you think there's room for improvement in their design, quality or cost, it would be a smart move to put your problems up to Scovill. Our long and varied experience in non-ferrous forgings has aided many manufacturers by providing them with either better products or lower costs. Let us put that experience to work for *you.*

GET THE FACTS

We'll be glad to send full details on how you can benefit by making Scovill *your* METAL-PART*ner.* Just fill in the coupon below and mail it today.

Scovill Manufacturing Company, Waterbury 91, Conn. *Export Department:* 405 Lexington Ave., New York 17, N. Y.



Please send me information about your metal-working facilities. I am interested in non-ferrous forgings for the applications checked:

- ☐ Aircraft
- ☐ Automobiles
- ☐ Band Instruments
- ☐ Blow Torches
- ☐ Cameras
- ☐ Communication Equipment
- ☐ Compressed Gas Cylinders
- ☐ Fire Extinguishers
- ☐ Household Appliances
- ☐ Industrial Instruments
- ☐ Plumbing Goods
- ☐ Pumps
- ☐ Valves
- ☐ Welding Equipment

Other applications.....

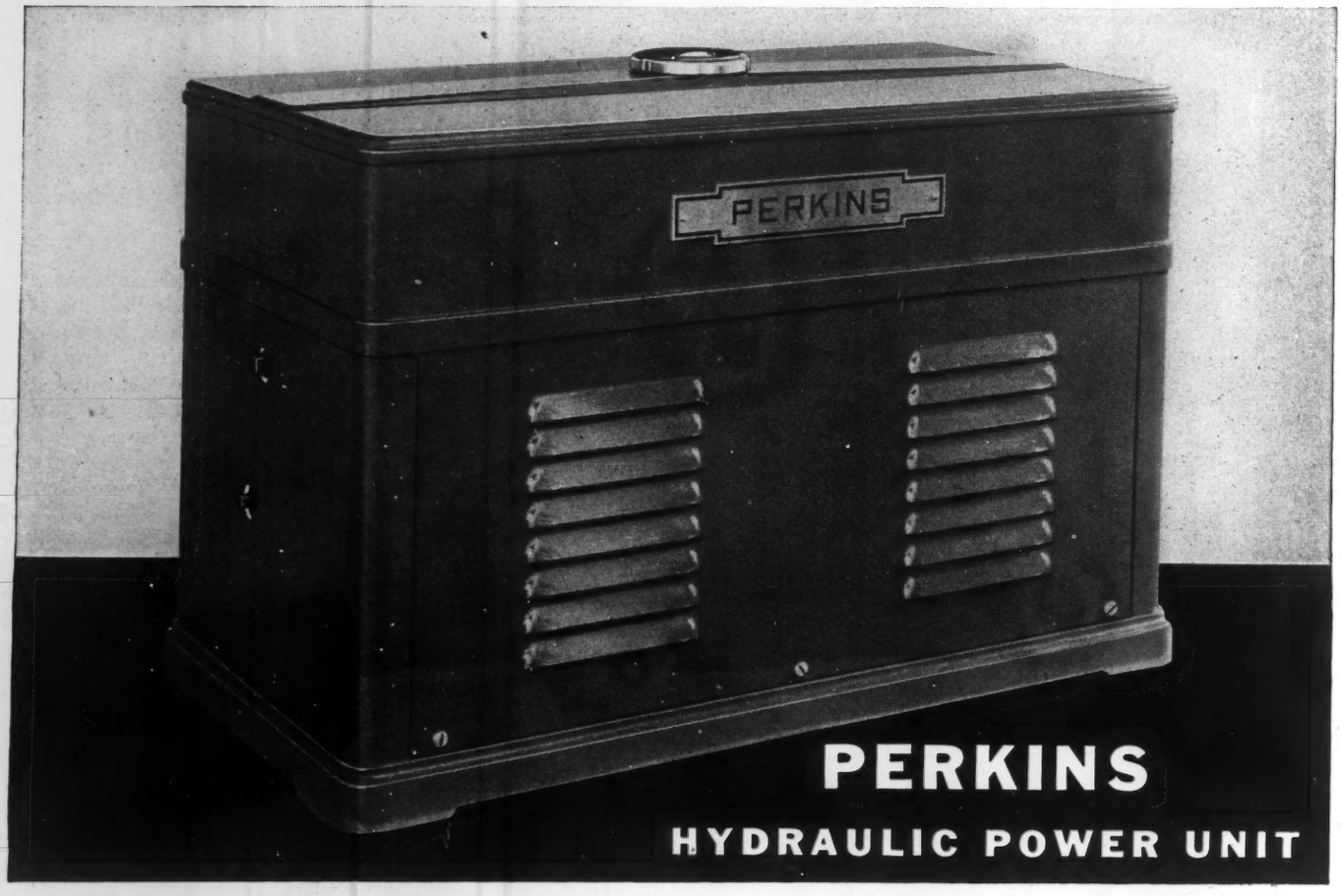
.....

SCOVILL MANUFACTURING COMPANY
Forgings Division
19 Mill Street
Waterbury 91, Connecticut

Name .....

Company .....

Address .....



THE entire mechanism—hydraulic pump, motor, valving, oil level gage, filter, and reservoir—all completely enclosed for maximum safety. All moving parts isolated from possible contact with clothing or hands and protected against damage.

3 G. P. M. to 12 G. P. M, 1200 P. S. I.
1-¼ G. P. M. to 5 G. P. M., 3000 P. S. I.
3 G. P. M., 5000 P. S. I.

½ G. P. M. to 1-¾ G. P. M., 10000 P. S. I.
Combination high and low pressure units to 12 G. P. M., 6000 P. S. I.

These compact hydraulic units operate laboratory and production presses, roll balancing devices, hydrostatic testing equipment, hydraulic controls, machine tools, arbor presses, etc. Complete engineering information for any particular application available.

B. F. PERKINS & SON, Inc.

Hydraulic Division

HOLYOKE, MASSACHUSETTS

Manufacturers of Industrial Machinery Since 1873

Pays for itself in 6 days

IN a plate mill, a Farval centralized lubricating system saved $500 per day by reducing rejections due to off-gauge rolling. Here's the story:

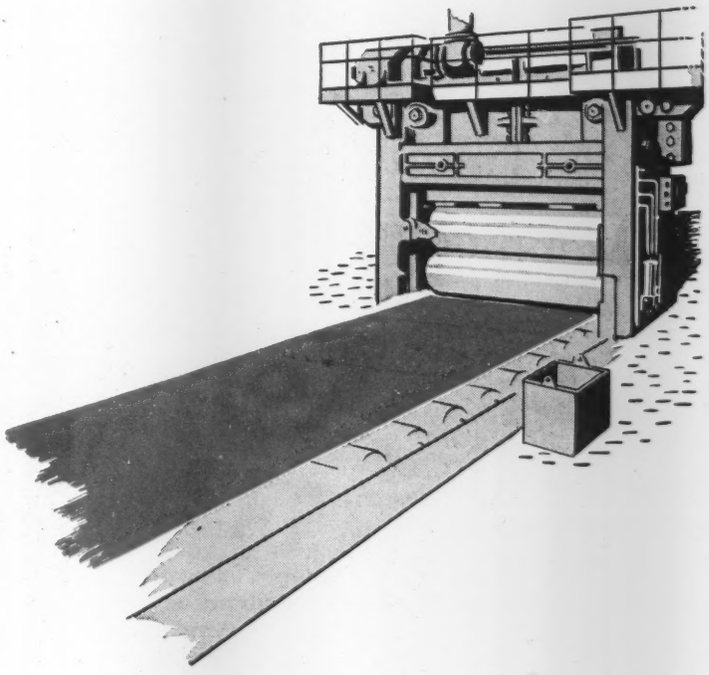
Hot and worn roll necks were causing bad gauge variation, curved plates, and plates running into the necks. Plate rejections were averaging 1½%. Farval was installed, bearing and neck wear became negligible, mill delays were reduced, and rejections for off-gauge dropped to half of one percent.

On the basis of rolling 300 tons per turn, this cut in plate rejections of one percent meant a saving of over $500 a day. Farval had cost less than $3000. It had paid for itself the first six days.

Farval delivers oil or grease under pressure to a group of bearings from one central station, in exact quantities, as often as desired. Farval—the Dualine System with the Positive Piston Displacement Valve—that has but 2 Moving Parts—is Fully Adjustable—and with a Tell-tale indicator at each bearing to show the job is done.

Substantial savings can be obtained by applying Farval on your equipment. Write for Bulletin 25. The Farval Corporation, 3265 East 80th Street, Cleveland 4, Ohio.

Affiliate of The Cleveland Worm & Gear Company, Industrial Worm Gearing. In Canada: Peacock Brothers Limited.



FARVAL—*Studies in Centralized Lubrication No. 81*

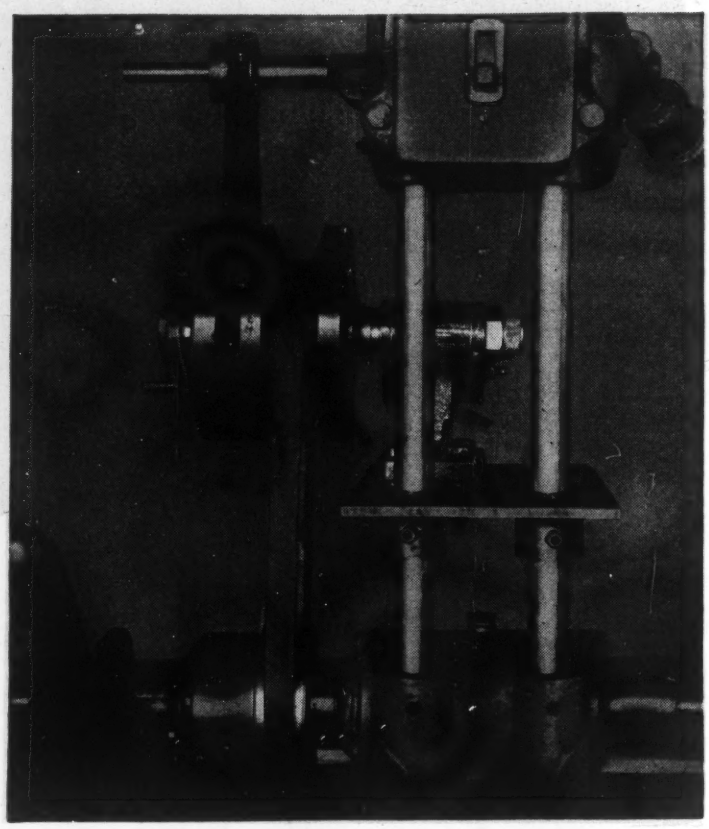
FARVAL
CENTRALIZED SYSTEMS OF LUBRICATION

American Speed-Jack Drives Give Your Equipment These 3 Advantages:

Higher Production

Lower Manufacturing Costs

Greater Flexibility



It's easy to give the equipment you design and build these 3 production advantages, with stepless speed-control provided by American Speed-Jack Drives. This unique drive permits simple adjustment of speed through a 3 to 1 ratio on the drives up to 1 H.P.

Since American Speed-Jack Drives can be quickly and easily mounted in any position in or on your machinery, these production advantages can be made available on equipment which has heretofore been limited in operation by single or multiple fixed-speed drives.

For example the plant manager responsible for the operation of the Platen Grinder illustrated above, reports that the installation of an American Speed-Jack Drive upped production 50%. At the same time manufacturing costs were cut in half!

And, American Speed-Jack Drives are readily adaptable to operation by remote control through the use of a compact flexible shaft. This facilitates panel mounting of the control when a centralized control panel is desired or when the unit is mounted in a hard-to-get-at location.

Add to these advantages sturdy construction, steel reinforced flanges and lubricated-for-life ball bearings. The result is a modern variable-speed drive which, when designed into the equipment you build, means more sales and larger profits. Write today for a copy of the Speed-Jack Drives Bulletin.

The American Pulley Company

4254 WISSAHICKON AVE., PHILADELPHIA 29, PA.

SEALMASTER BALL BEARING UNITS

PERMANENT SEAL
SealMaster's patented centrifugal seal retains lubricant and excludes dirt.

SELF-ALIGNING
The bearing assembly is self-aligning in the housing. Shaft misalignment cannot distort the seal.

PRE-LUBRICATED
All SealMasters are shipped with the lubricant sealed in—ready for immediate service.

LOCKING PIN
Patented locking pin positions unit for re-lubrication and prevents rotation of outer race in housing, thus eliminating housing wear.

No Housing Wear...Quiet in Operation!

Important engineering features, combined exclusively in SealMaster ball bearing units, have placed SealMasters out in front for all-around top bearing performance. These features include a permanent seal, self-alignment without seal distortion, and a patented locking pin which prevents rotation of the outer bearing race in the housing, thus eliminating housing wear. Add these important advantages to your product by incorporating SealMasters in your design.

Now is a good time to check SealMaster's advantages! Write today for catalog 845 which gives dimensions, load ratings and full engineering data on the complete SealMaster Line.

BEARING DIVISION

STEPHEN S-A ADAMSON MFG. CO.

18 RIDGEWAY AVENUE, AURORA, ILLINOIS

LOS ANGELES, CALIF. ★ BELLEVILLE, ONT.

Factory Representatives and Dealers in All Principal Cities

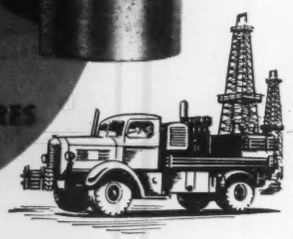
New! CHIKSAN XH

(EXTRA HIGH PRESSURE)

SWIVEL JOINTS

FORGED STEEL

for WORKING PRESSURES to 12,000 psi



The new forged steel CHIKSAN XH Swivel Joint combines the easy turning and effective pack-off—for which all CHIKSAN Joints are noted—with high capacity. Built of forged steel, with flame-hardened races, this new CHIKSAN Joint is designed for heavy duty services of all kinds. It makes possible the fabrication of all-steel lines with perfect flexibility, yet capable of withstanding working pressures to 12,000 psi...with greater safety and longer life. Engineering data on request.

In addition to the new CHIKSAN XH forged steel Swivel Joint, there are over 500 different Types, Styles and Sizes available for pressures from 300 to 3000 psi, and temperatures to 500° F.

REPRESENTATIVES IN PRINCIPAL CITIES

EXPORT REPRESENTATIVE: Chiksan Export Co., Brea, Calif.
Branches: New York 7, Houston 2

CHIKSAN

BALL BEARING SWIVEL JOINTS FOR ALL PURPOSES

CHIKSAN COMPANY
BREA, CALIFORNIA
New York 7 Houston 2

on new or old designs....

CHICAGO *"Safety Plus"* means *extra* holding power

Precision-made Chicago "Safety Plus" Products are the solution to many current production problems.

Exacting inspection standards insure sharp, full threads, uniform pitch diameter and clean true sockets. "Safety Plus" Products are manufactured from the finest selected heats of electric furnace alloy steel which provides added strength, toughness—and EXTRA holding power.

These outstanding features combine to make a truly fine product—ideally suited to modern production methods.

Chicago "SAFETY PLUS" line includes:

Socket Head Cap Screws • Socket Set Screws • Stripper Bolts • Square Head Dog Point Set Screws • Socket Pipe Plugs • Keys for "Safety Plus" Products.

Complete line includes:

Hexagon Head Cap Screws • Square Head Cup Point Set Screws • Headless Set Screws • Fillister Head Cap Screws • Flat Head Cap Screws • Taper Pins • Milled Studs • Semi-Finished Hexagon Nuts • Semi-Finished Hexagon Castellated Nuts.

These Fine Products are sold only thru Authorized Distributors

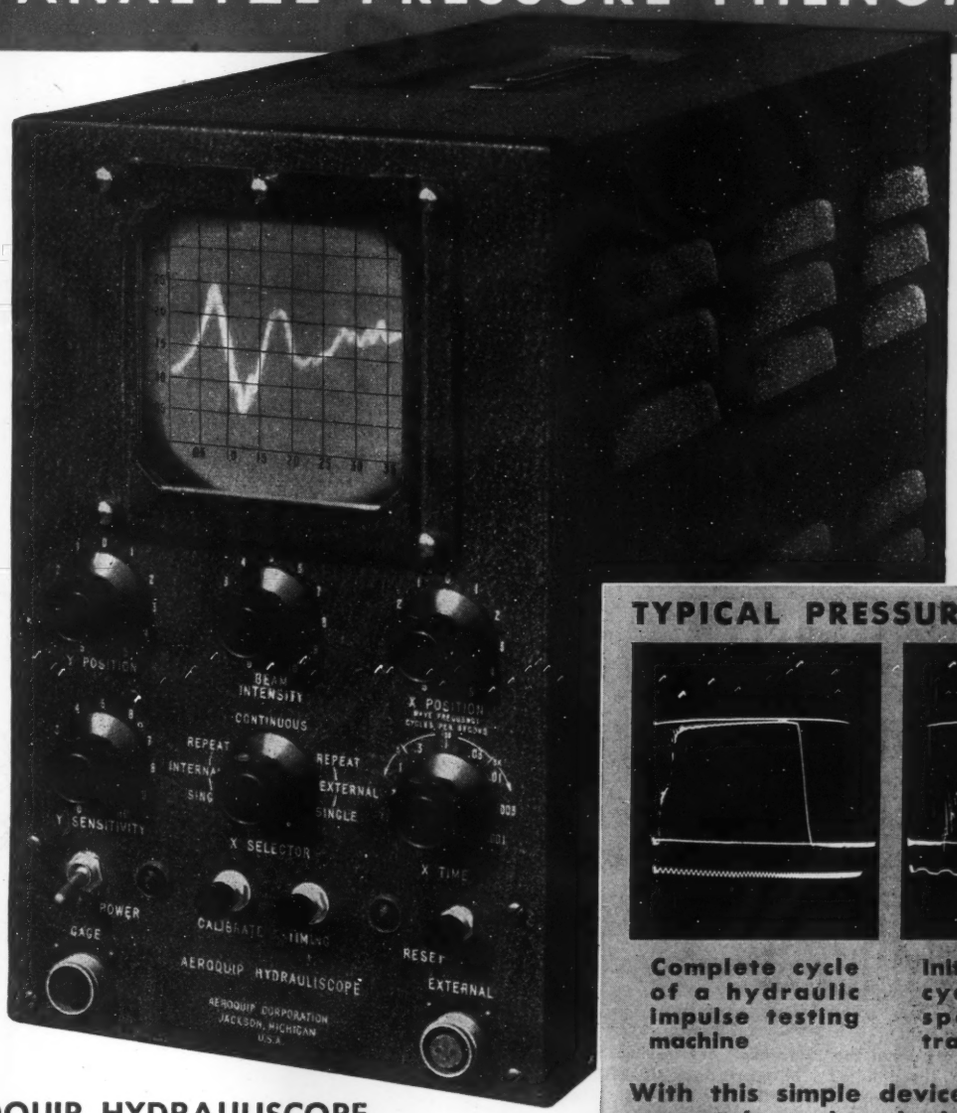
THE CHICAGO SCREW CO.
ESTABLISHED 1872
1026 So. HOMAN AVENUE CHICAGO 24, ILL.

THE AEROQUIP HYDRAULISCOPE*

TO ANALYZE PRESSURE PHENOMENA

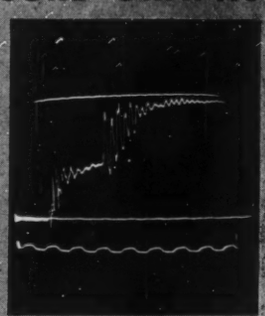
*Reg. Trade Mark

19472



TYPICAL PRESSURE GRAPHS

Complete cycle of a hydraulic impulse testing machine



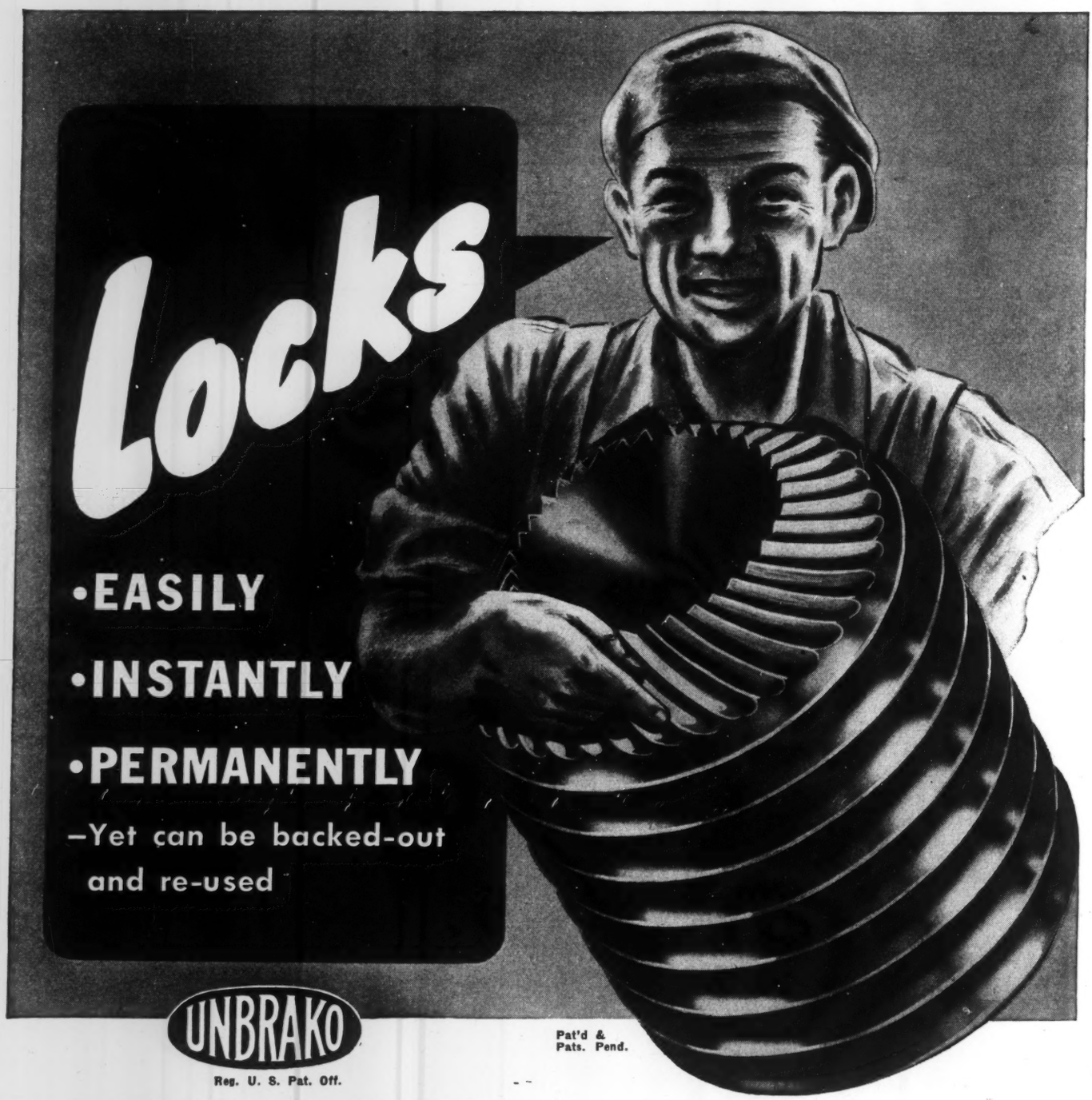
Initial portion of cycle with the speed of time trace increased

With this simple device anyone can accurately analyze hydraulic pressure phenomena.

The AEROQUIP HYDRAULISCOPE is a high speed electronic analyzer, compact and portable, giving consistent results even when used by persons unfamiliar with electronic devices.

AEROQUIP CORPORATION

JACKSON, MICHIGAN



UNBRAKO

Reg. U. S. Pat. Off.

Pat'd & Pats. Pend.

Yes, Sir—that's just what the "Unbrcko" Self-locking Socket Set Screw with the Knurled Cup-point does—IT LOCKS—EASILY, INSTANTLY AND PERMANENTLY!—from the very smallest to the largest size made. That knurled cup-point digs-in and really tckes hold—regardless of the most chattering vibration.—AND IT CAN BE EASILY BACKED-OUT AND USED OVER AND OVER AGAIN.

Yes, Sir—that's why there are millions in use.

The "Unbrako" Catalog contains complete information—write for your copy today.

"Unbrako" and "Hallowell" products are sold entirely through distributors.

Knurling of Socket Screws originated with "Unbrako" in 1934.

You can't screw socket screws in or out, without a hex socket wrench, so why not get our #25 or #50 "Hallowell" Hollow Handle Key Kit which contains most all hex bits.

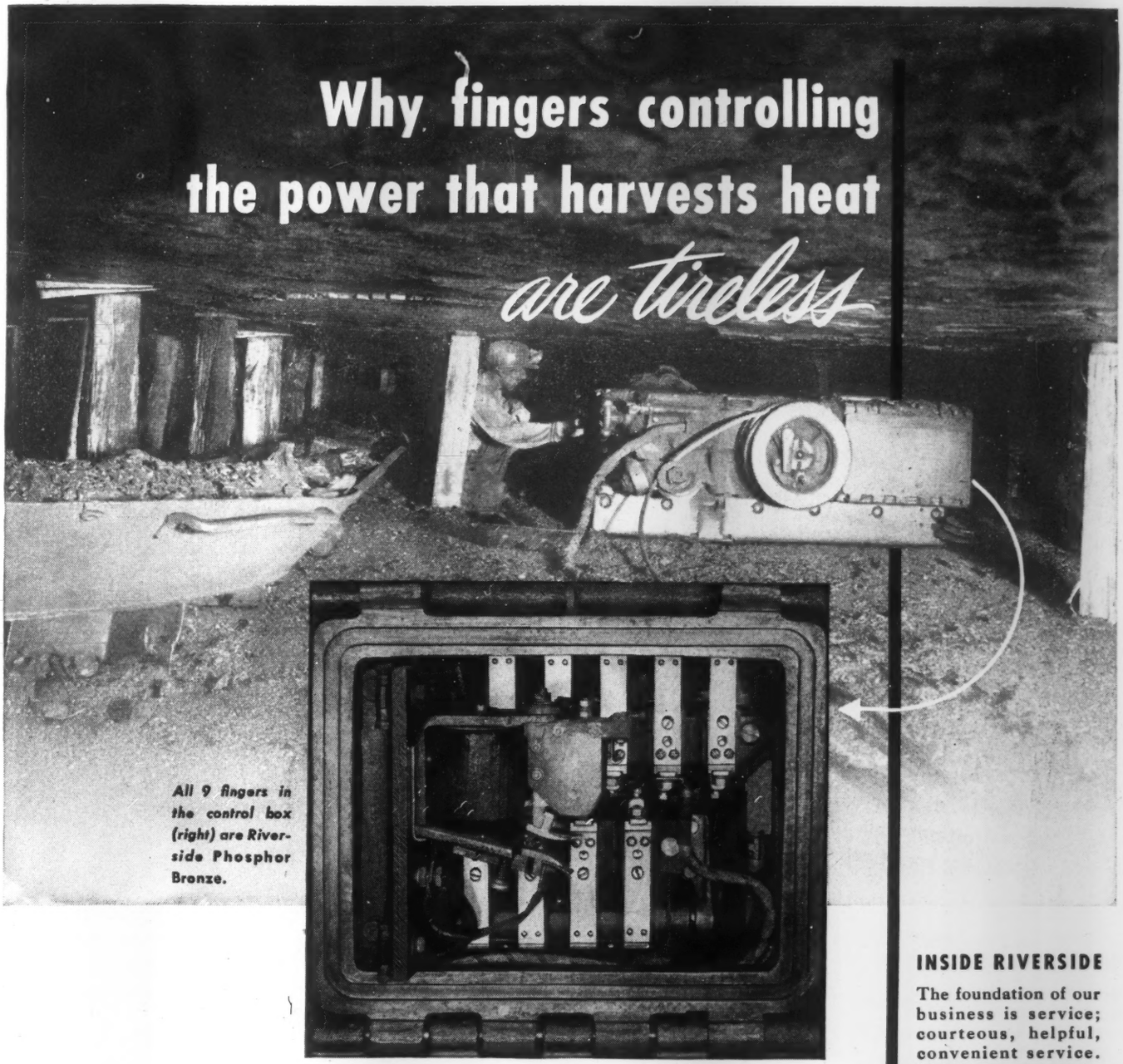
Kit: Pats. Pend.

OVER 43 YEARS IN BUSINESS

STANDARD PRESSED STEEL CO.

JENKINTOWN, PENNA., BOX 102 • BRANCHES: BOSTON • CHICAGO • DETROIT • INDIANAPOLIS • ST. LOUIS • SAN FRANCISCO

Why fingers controlling the power that harvests heat *are tireless*



All 9 fingers in the control box (right) are Riverside Phosphor Bronze.

RIVERSIDE PHOSPHOR BRONZE IN ACTION

Gnawing out a seam of coal in close quarters is a man's size job for tough equipment.

The power for operating the Goodman shortwall coal cutting machine flows through contact fingers made of Riverside *Phosphor Bronze*. These fingers resist corrosion and bear up under repeated flexure. The unusual fatigue strength of Riverside *Phosphor Bronze* and resistance to atmospheric conditions make it especially valuable and economical for critical current carrying springs. Riverside *Phosphor Bronze* is one of three families of alloys in which we specialize. Interesting booklets about Riverside *Phosphor Bronze*, *Nickel Silver* or *Beryllium Copper* are yours for the asking.

INSIDE RIVERSIDE

The foundation of our business is service; courteous, helpful, convenient service. This is one reason why we have sales offices strategically located in New York, Chicago, Cleveland and Hartford. Please ask us for help whenever the need arises.

RIVERSIDE

THE
RIVERSIDE METAL COMPANY
NEW YORK CHICAGO RIVERSIDE • NEW JERSEY HARTFORD CLEVELAND

BRIGGS & STRATTON
ENGINES

A Re-Statement of Policy

Loyalty to our customers of long standing... their needs come first.

Production at highest possible levels... limited only by availability of materials that meet our exacting specifications.

No deviation from Briggs & Stratton high standards of engineering, manufacture and inspection.

Expansion of our world-wide organization of Authorized Service Stations... staffed with skilled, factory-trained personnel, and adequately supplied with repair parts.

These policies, re-affirmed now, are continued assurance to equipment manufacturers, dealers and users that "It's powered RIGHT... when it's powered by Briggs & Stratton".

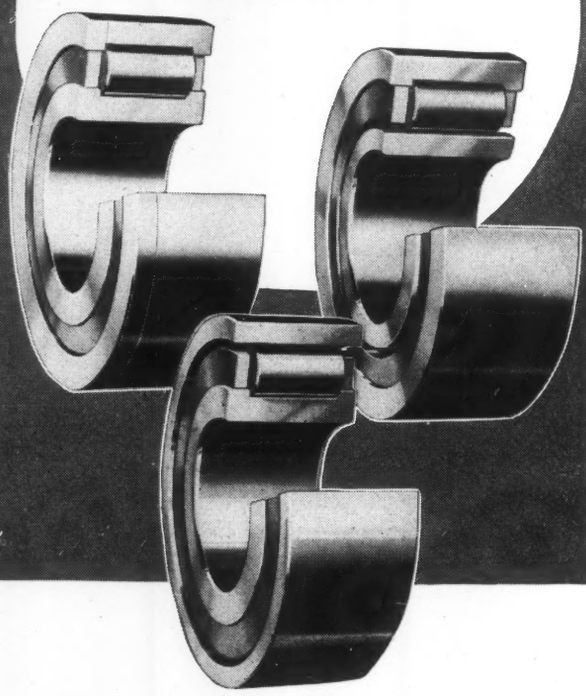
BRIGGS & STRATTON CORPORATION
Milwaukee 1, Wisconsin, U. S. A.

Air-Cooled Power

4 CYCLE
BRIGGS & STRATTON
GASOLINE ENGINES

Big Smoothies

AMERICAN RADIAL ROLLER BEARINGS



For nearly every application where the load is radial you'll find an AMERICAN RADIAL ROLLER BEARING to meet your requirements. Engineered to exacting standards, precision tested, specially designed for smooth, reliable operation under tremendous loads, AMERICAN RADIAL ROLLER BEARINGS function flawlessly in the heaviest equipment built and under the most rigorous operating conditions encountered in any industry.

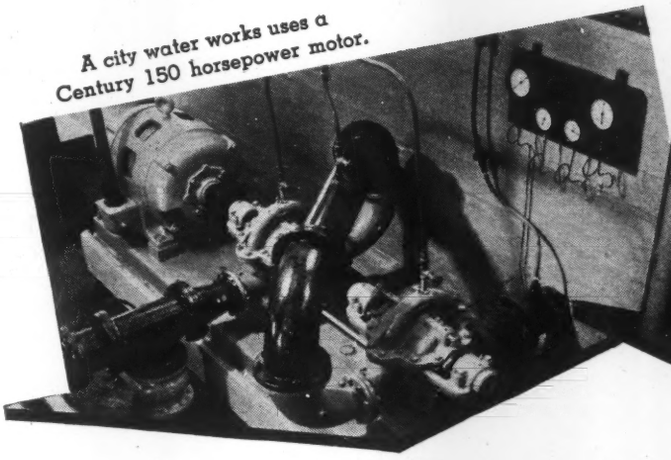
AMERICAN RADIAL ROLLER BEARINGS come in 5 styles, 4 S.A.E. series and 85 sizes. Special designs to order are also available. Our engineers will cooperate with your own technical staff on all your roller bearing problems.

AMERICAN ROLLER BEARING COMPANY
Pittsburgh, Pennsylvania

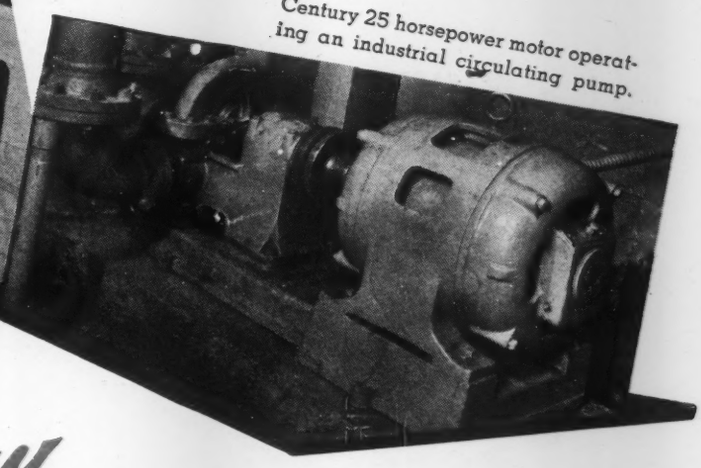
Pacific Coast Office:
1718 S. Flower St., Los Angeles, California

AMERICAN ROLLER BEARINGS
HEAVY DUTY

AMERICAN
Heavy-Duty ROLLER BEARINGS



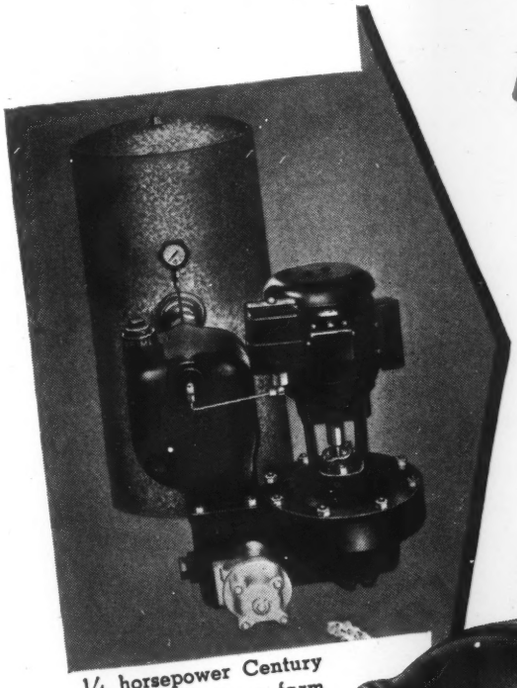
A city water works uses a Century 150 horsepower motor.



Century 25 horsepower motor operating an industrial circulating pump.

Century

Moisture Protected PUMP MOTORS Assure Dependable Power for Water Supply



1/4 horsepower Century motor operates a farm water system.

- On Farms
- For City Water Supply
- In Industrial Plants
- For Fire Protection

Century's triple insulation is especially effective in resisting high humidity and dampness — thus the windings are protected against premature deterioration.

Hundreds of thousands of Century motors are providing a long life of satisfactory service on pump installations of many kinds and sizes, from small fractional horsepower farm water systems to large city and industrial pumping plants.

They start quietly, run quietly and with an unusual freedom from vibration.

Century motors are built in a wide range of types, in sizes from 1/6 to 400 horsepower — for any type of pumping service — in any climate — and all other electric power applications. Specify Century motors for all your electric power requirements.

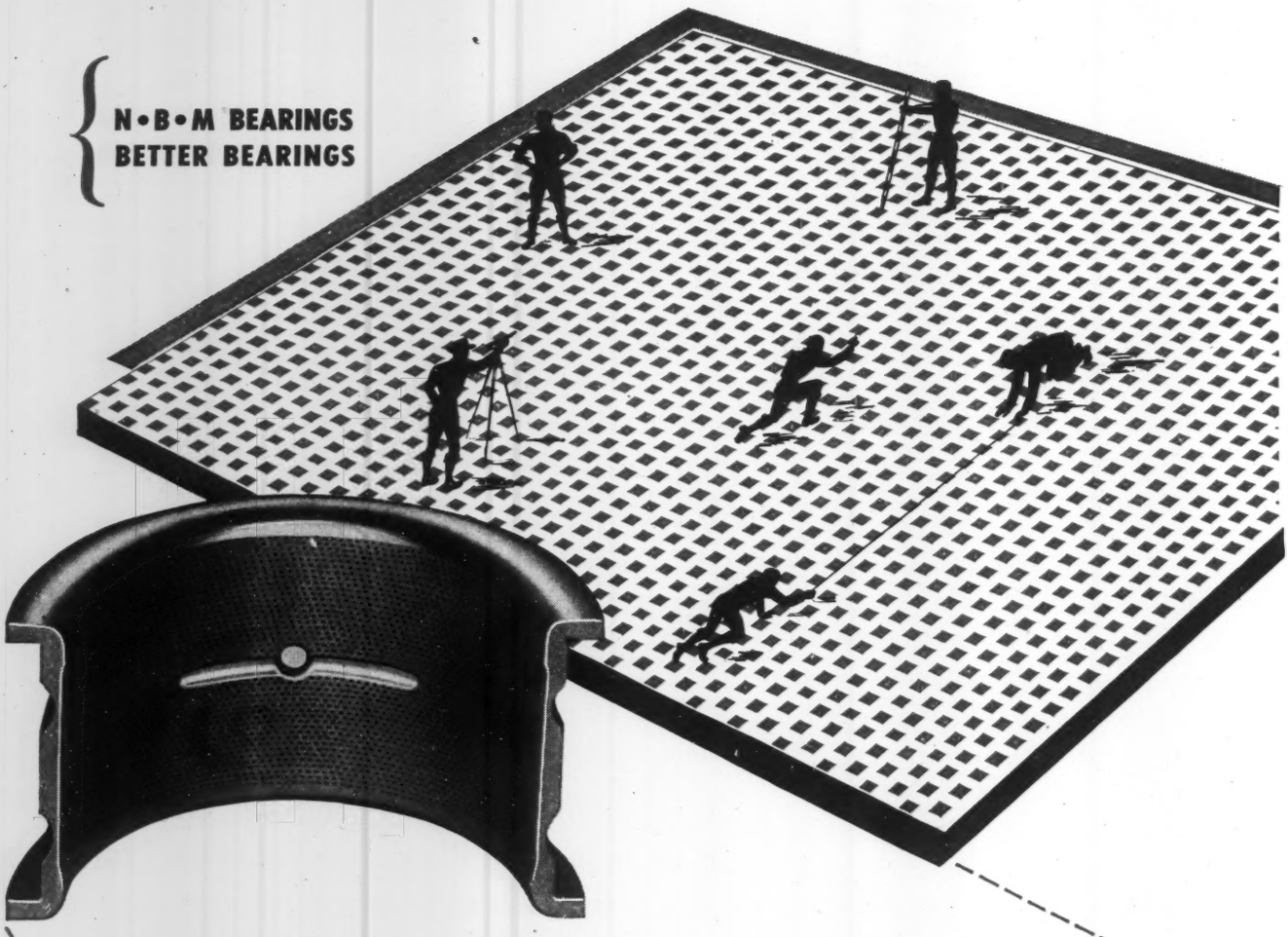
Century C MOTORS

503

CENTURY ELECTRIC COMPANY 1806 Pine St., St. Louis 3, Mo.

Offices and Stock Points in Principal Cities

N•B•M BEARINGS
BETTER BEARINGS



N•B•M GRIDDED BEARINGS

WITH PRECISION-SPACED LANDS AND GRIDS

The most efficient predetermined proportions of lands and gridded areas are produced automatically by special Brake Shoe Research-perfected tools.

When frictional heat causes the Silver Babbitt in the grids to flow, it will wipe over the bearing surface and cover it evenly. Shaft and bearing are protected from fatigue, seizure, and overstress. Moreover, the uniform pattern of small, isolated grids prevents the development of faults and cracks.

Please ask us for detailed information.

NBM

American Brake Shoe

NATIONAL BEARING DIVISION
ST. LOUIS • NEW YORK

PLANTS IN: ST. LOUIS, MO. • PITTSBURGH, PA. • MEADVILLE, PA. • JERSEY CITY, N. J. • PORTSMOUTH, VA. • ST. PAUL, MINN. • CHICAGO, ILL.

Wichita City Lib.

HELPFUL LITERATURE

FOR DESIGN EXECUTIVES

1. Bearings & Bushings

National Formetal Co.—16-page illustrated catalog on Superformed Formetal bushings and bearings describes wide range of bronze, brass and steel bushings, bearings and spacer tubes. Engineering and design data are included on applications, alloys, tolerances and groove patterns.

2. Transient Recorder

Brush Development Co.—6-page illustrated bulletin form No. 589 contains technical information on transient recorder which is designed to record and graphically represent many kinds of transient phenomena of less than 1/10-second duration. Phenomena can be electrical or capable of being picked up by electrical gages.

3. Sketch Pad

Jiffy Sales Co.—1-page data sheet describes features of Jiffy Sketch scale drawing pad of tissue sheets which can be laid over isometric and scaled sheets to guide user in making sketches or line drawing. Scaled sheets are part of pad. Tracing sheets in pad can be removed by tearing on perforation.

4. Small Motor

Alliance Mfg. Co.—1-page illustrated data sheet No. 1076 describes model MS shaded pole induction type motor which can be made for voltages from 24 to 250 on 40, 50 or 60-cycle alternating current. Full load torque is 0.75-ounce-inch at 2800 revolutions per minute.

5. Induction Heating

Ohio Crankshaft Co., Tocco Div.—59-page illustrated treatise "Induction Heating" by H. B. Osborn, Jr. traces history, developments and applications of this heating method. Principles, technical considerations, equipment and other factors are discussed.

6. Flexible Couplings

Climax Flexible Coupling Co.—4-page illustrated bulletin No. 51 shows standard, light and heavy duty couplings which are available in type and size for practically any direct connected drive application. Specifications, ratings and application data are given.

7. Gasoline Engine

Clinton Sales Co.—6-page illustrated folder form No. 501 describes Clinton all purpose 4-cycle gasoline engine for powering tractors, scooters, power plants, spray equipment, farm equipment and other units. Dimensional data and specifications are given.

8. Oil Purification

Honan-Crane Corp.—Illustrated publication "Clean Oil" is devoted to oil purification equipment. Specific applications are covered and case histories are cited of equipment used in manufacture of plastics, metal products, drop forgings, grinding wheels and abrasives.

9. Power Transmission

Boston Gear Works, Inc.—320-page illustrated vest pocket size catalog No. 54 contains complete information on company's line of transmission equipment and component machine parts. Specifications and prices on thousands of parts are given and number of applications are cited.

10. Motor Brushes

Ohio Carbon Co.—12-page illustrated folder is listing of frames, models, types and other data on electric motors, with recommended brush numbers tabulated. Contents of motor brush kit No. 35A are shown.

11. Foot Operated Valves

Hanna Engineering Works—4-page illustrated bulletin entitled "Hanna Foot Operated Valves to Help Busy Hands" describes single and double pedal operated valves for control of air and hydraulic cylinders. Design, operation, specifications and features are presented.

12. Tubing

Babcock & Wilcox Tube Co.—4-page technical data card No. 103-B lists wire and sheet metal gage equivalents, equivalents for fractions of inch and tabulates line of seamless and welded tubular materials produced by company.

13. Metal Base Relays

Ward Leonard Electric Co.—4-page illustrated folder No. 104 describes Midget metal base relays for use in small radio transmitters, aircraft control circuits and other applications where space is limited. Coil and contact data, contact arrangement and dimension sketches cover both standard and heavy duty units.

14. Weldments

Lukenweld, Inc.—28-page illustrated bulletin "Weldments Designed and Fabricated by Lukenweld" presents condensed specifications of typical units fabricated by welding methods. These range from engine frames to pump casings. Facilities of company are described.

15. Synthetic Rubber

United States Rubber Co.—50-page booklet "Five Years of Synthetic Rubber" describes industry and gives appraisal of its importance in the manufacture of rubber goods. Types of synthetic rubber are identified and described. Properties of each are listed. Included is glossary of terms employed in industry.

16. Obsolescence

Bunell Machine & Tool Co.—8-page booklet "Obsolescence in Men, Methods & Machines" discusses all phases of this subject with particular emphasis on its effects on production.

17. Reproduction Materials

General Aniline & Film Corp., Ozalid Div.—20-page illustrated sample folder "10 Types of Prints Instead of 1" contains samples of prints produced on Ozalid reproduction machines. Print types include black, blue and red line; opaque cloth; transparent black, sepia and cloth; transparent foil; Chartfilm and Dryphoto.

18. Tool Specialties

Jergens Tool Specialty Co.—Multiple-page looseleaf catalog and price list presents detailed drawings of wide range of precision parts and specialties which include washers, strap clamps, hand knobs, thumbscrews, flange nuts, jig parts, fixture keys, studs, handwheels, chuck jaws, crank handles, levers and other machined parts.

19. Precision Casting

Kerr Mfg. Co.—Two illustrated catalogs entitled "Fundamentals of Precision Casting" and "Precision Casting Equipment and Materials" trace history of "lost wax method" of precision casting and describe specialized materials and equipment necessary for use. They are published especially for designers and engineers who can use method in precision manufacturing procedures.

20. Photo Sensitizing

Eastman Kodak Co.—20-page illustrated bulletin entitled "Kodak Linagraph Transfer Paper" points out possible applications of this material which can be used to sensitize sheets of metal, plastic, wood, glass and other materials for the production of templates, dials, scales, grid lines, etc. Procedures are outlined.

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21. Hydraulic Flow Regulators

Waterman Engineering Co.—4-page illustrated bulletin presents information on constant flow regulators for hydraulic systems for regulating flow of liquid under varying loads. Data and price sheet is included as supplement.

22. Thermosetting Resin

B. F. Goodrich Chemical Co.—12-page illustrated technical bulletin "Kriston Thermosetting Resin" covers properties and processing information for thermosetting allyl ester casting resin. It can be cast in transparent, translucent or opaque colors for lenses, dial indicator crystals, light shields or sign parts.

23. Rotary Pumps

Blackmer Pump Co. — 40-page illustrated catatog No. 106 covers entire line of rotary pumps and lists liquids being handled and types of original equipment on which they are used. Design and operating data, dimensional charts, typical installations, horsepower requirements and capacity and horsepower tables are given.

24. Electric Motors

Brown-Brockmeyer Co. — 6-page illustrated bulletin No. 5000 presents details of line of electric motors in capacities from 1/8 to 30 horsepower. Brief descriptions are given of twelve different types, including geared head motors.

25. Recording Tachometers

Bristol Co.—12-page illustrated bulletin No. S1400 describes line of tachometer recorders and indicators. Complete wiring diagrams, application data and accessory information are given.

26. Aluminum Heat Treatment

Reynolds Metals Co. — 144-page illustrated handbook explains proper methods of heat treatment of aluminum alloys. Written for both nontechnical reader and highly trained technician, this book covers entire field of heat treatment of aluminum alloys. It contains numerous tables, photomicrographs and charts.

27. Textile Counters

Durant Mfg. Co.—16-page illustrated catalog No. 50 describes Pick counter models and other standard Productimeters for use in textile industry. Units for all types of textile work are covered. Descriptions, specifications, application data and installation information are given.

28. Pipe & Fittings Chart

Tube Turns, Inc. — 4-page loose-leaf file chart of pipe and fitting materials deals with carbon, intermediate alloy, stainless and special analysis steels and covers ASTM specifications, chemistry, service limitations and welding procedure. Chart measures 9 x 14 inches and is prepared for engineers, draftsmen and others concerned with design, buying, layout and erection of piping systems.

29. Tube Bending

Republic Steel Corp., Steel & Tubes Div.—78-page illustrated pocket-size booklet "The Bending System" has been prepared to explain ease and accuracy with which Inch-Marked Electrunite E.M.T. tubing can be worked. Use of bender, features of tubing, data on tubing and installation, and electrical information are included.

30. Centrifugal Pump

Worthington Pump & Machinery Corp.—8-page illustrated bulletin No. W-341-B11 deals with saddle mounted, vertically split, centrifugal pumps, types HR and HB single and two stage volute for boiler circulation and heater drain service. Twenty sizes of pumps are available for capacities of up to 1800 gallons per minute at heads up to 900 feet.

31. Reproduction Materials

Hunter Electro-Copyist, Inc.—17-page illustrated looseleaf catalog "Reproduction Papers for the Hunter Electro-Copyist" contains samples of work reproduced on various types of Hecco-Dyzed papers and tracing cloth. Details are given on various models of photoprinting machines and on developing chemicals.

32. Split Ball Bearings

Split Ballbearing Corp.—4-page illustrated folder "Split Ball Bearings" presents data on bearing with divisible races for application in assemblies where solid race bearings can not be used. Typical installations are illustrated and include applications in connecting rod bearing, pumps, fan, propeller shaft and machine tool transmission shaft.

33. Electrical Instruments

Marion Electrical Instrument Co.—12 page illustrated brochure "Sealed Like a Vacuum Tube" presents potentialities of hermetically sealed glass-to-metal electrical indicating instruments for use in all types of electrical equipment.

34. Carbon-Graphite

United States Graphite Co.—40-page illustrated booklet describes "Graphitar" carbon-graphite nonmetallic material that resists chemical attack. Its characteristics, typical applications, advantages and physical properties are outlined. Specification sheet for use of designers requiring specific data is included.

35. Hydraulic Power Unit

John S. Barnes Corp.—2-page bulletin No. 304-U lists specifications of model F-20-A hydraulic power unit which is suitable for applications requiring 2 or 5-horsepower output. Maximum delivery is 12½ gallons per minute with maximum pressure of 1000 pounds per square inch.

36. Condenser Tubes

Wolverine Tube Div., Calumet & Hecla Consolidated Copper Co. — 16-page illustrated booklet form No. S-294 includes tables designed to aid in selection of materials for condenser tubes. Comprehensive graph gives safe working pressures. Estimating data covering tube sizes from 5/8 to 2 inches outside diameters are included.

37. Gears & Reducers

Ohio Gear Co.—4-page illustrated bulletin "Ohio Gears-Reducers" presents brief descriptions of available stock gears and stock speed reducers. Ratios of reducers range from 4-1 to 3200-1 in single reduction capacities from 1/6 to 10 horsepower and in double reductions from 25 inch-pounds to 3200 inch-pounds torque.

38. Control Valves

Foxboro Co.—36-page illustrated bulletin No. 277-1 describes control, needle type, poppet and butterfly valves. Information is included to aid in computing valve size for contemplated installations. Filters, ventilating dampers and other accessory equipment are included.

39. Adjustable Transformers

General Radio Co.—8-page illustrated catalog No. 424-F-404607 presents Variac continuously adjustable transformers for all types of voltage, power, speed and heat controls. Charts diagram input and output of all models and general specifications are given.

40. Hose Couplings

Eastman Mfg. Co.—40-page illustrated catalog No. 46-A is compilation of information on renewable couplings, barbed insert couplings, adapters and assemblies for hose couplings and accessories. Cross sectional drawings and exploded photographs cover application and construction.

41. Ball Bearings

Miniature Precision Bearings, Inc.—4-page illustrated folder No. 4b/1 features ball bearings for precision instruments and mechanisms. In addition to radial, Super-Light and pivot series, new angular contact and thrust series are described and illustrated. Specifications are included.

42. Pipeline Welding Fittings

Bonney Forge & Tool Works—20-page illustrated catalog No. WT 46 presents application information, structural data, installation procedure, temperature-pressure ratings, specifications and list prices of fittings for making full pipe strength leakproof branch pipe outlets. Also described are drain-out fittings and flanges.

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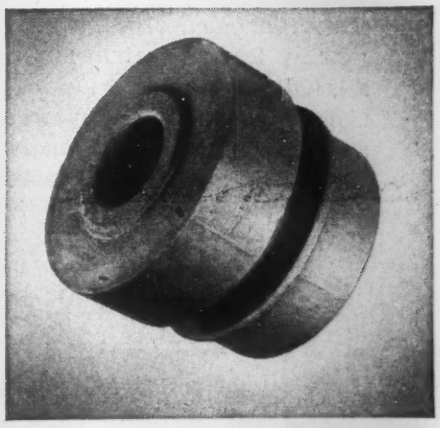
"Let's change this cast part to a forging . . .
. . . better get in touch with Tube Turns"

NOTHING equals a forging for ability to take a beating. Forgings are not subject to the weaknesses characteristic to castings — porosity, shrinkage cracks, hot tears—the cause of many rejects and failures. Many a mechanical product can be strengthened and improved by changing to forgings for vital parts. So send your prints for the recommendations of TUBE TURNS' engineers. Get lined up for some realistic production by an outstanding forge shop. Forgings *can* be had, if you deal with TUBE TURNS—better forgings.

Experienced, skillful personnel operates modern high-speed, heavy-duty mechanical presses and upsetters and this equipment is coordinated under one roof with complete die designing, die making, laboratory, and rough machining facilities. Your job benefits by a highly desirable continuity of effort. TUBE TURNS (Inc.), Louisville 1, Ky.

DISTRICT OFFICES at New York, Washington, D. C., Philadelphia, Pittsburgh, Cleveland, Detroit, Chicago, Houston, San Francisco, Los Angeles.



Gear forging. Typical of the "round jobs" which are a TUBE TURNS specialty—forgings which require maximum tensile strength, must be economically turned out in mass-production quantities.

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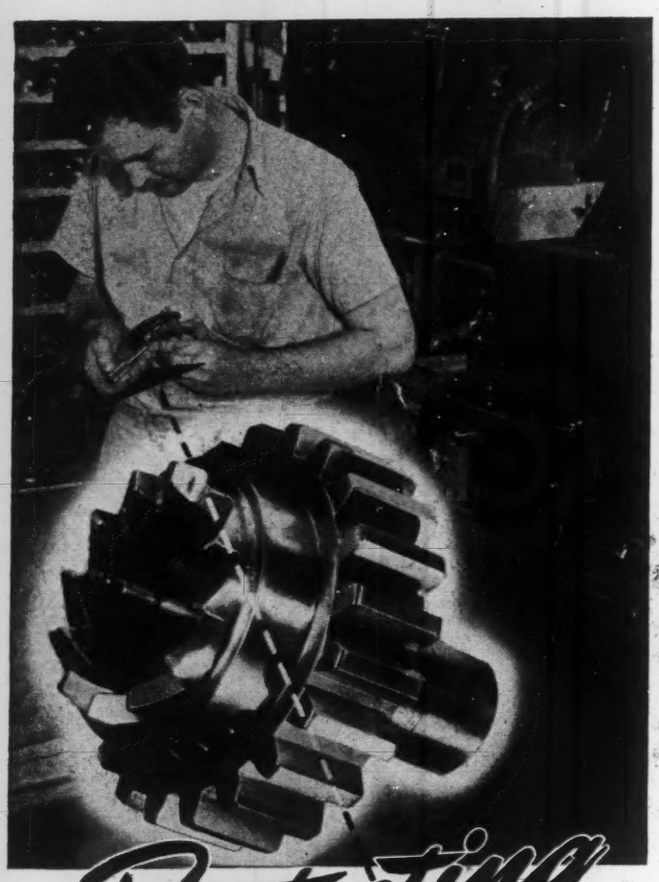

Protecting PRECISION

At Indiana Gear Works, every precision-wise craftsman is his own stern critic . . . every worker an *inspector,* in effect. That's why, when you turn your precision gear and parts problems over to IGW, you can be sure *every* unit will meet your most exacting specifications . . . or *you* never see it!

Many leading manufacturers have found this IGW system of interlocking precision controls is positive protection against costly time and money losses due to turn-backs and discards. You can read their "case histories" by writing for a free copy of *Precision Doesn't Cost*—IT PAYS!

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GEARS • CAMS • INTRICATE AND PRECISE MACHINE PARTS

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THERE IS ONLY ONE "Pressed-On" COUPLING FOR HIGH PRESSURE HYDRAULIC CONTROL HOSE . .

PATENTED GRIPPING

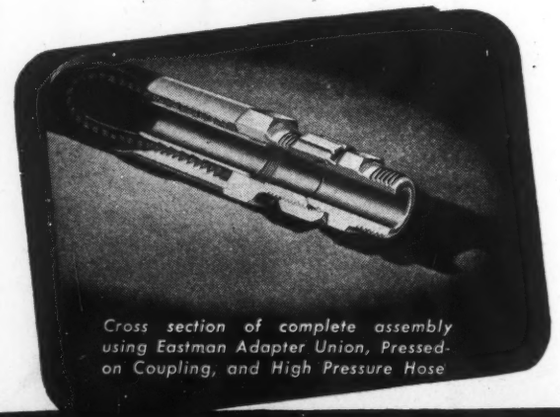
feature makes the bond of the Eastman "Pressed - On" Coupling to the hose stronger than the hose itself. Brass Couplings are one piece construction. Designed for heavy duty and maximum flow through coupling.

WHEN YOU SPECIFY

"Pressed-On" Couplings with Eastman Adapter Unions and High Pressure flexible wire-braided hose you can be sure of a leak-proof, durable hydraulic control hose assembly.

BE SURE!

Specify Eastman hydraulic control hose units. Write The Eastman Mfg. Co., Manitowoc, Wis.

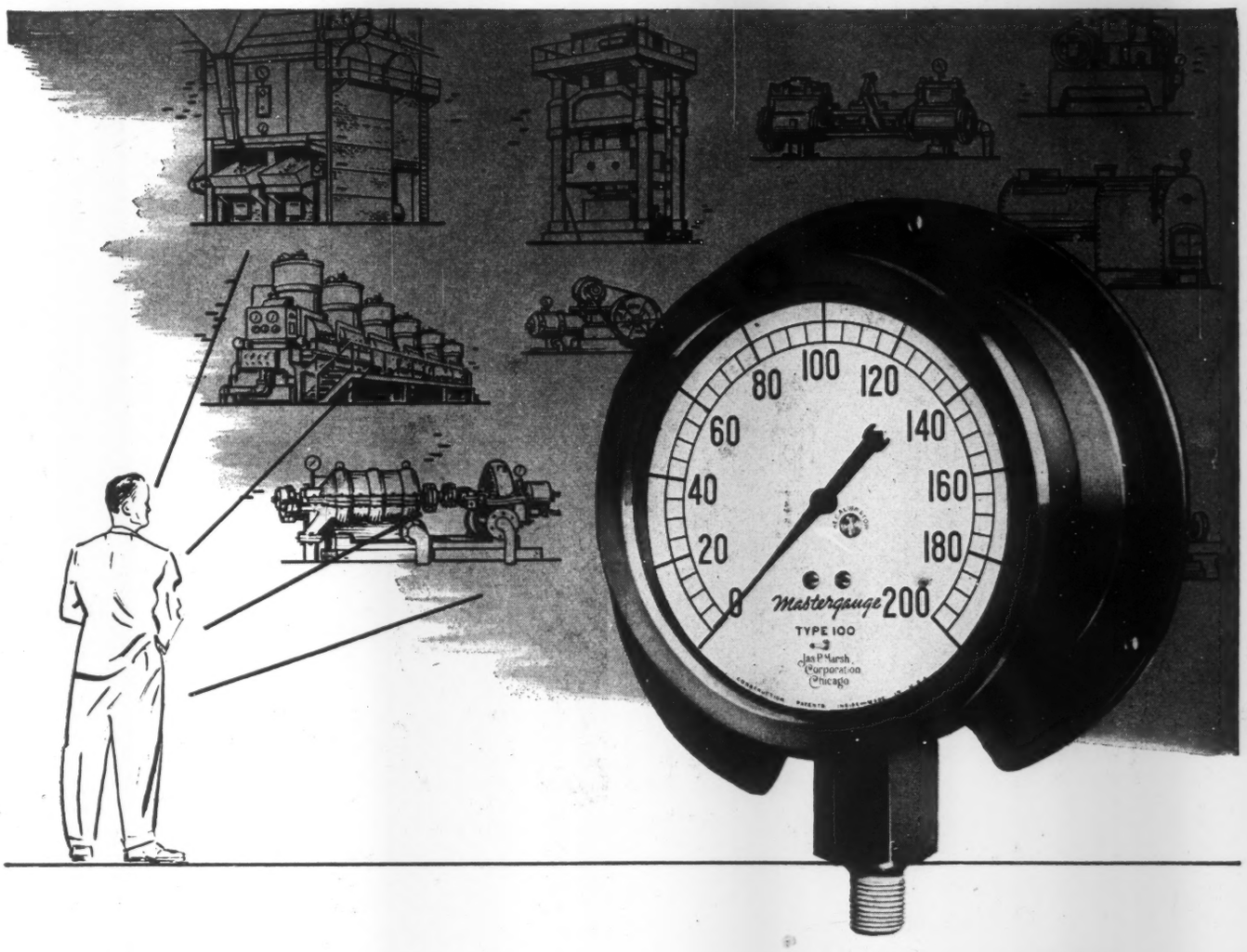


Cross section of complete assembly using Eastman Adapter Union, Pressed-on Coupling, and High Pressure Hose

THE EASTMAN MFG. CO.

1002 N. Eleventh St., Manitowoc, Wisconsin

PIONEER MANUFACTURERS OF HOSE COUPLINGS



Between you...and Trouble—

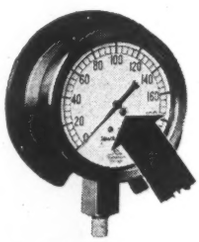
What's going on inside that boiler . . . tank . . . compressor . . . pump . . . forging press? It takes a pressure gauge to tell the story—and a good one to tell it right.

Keep that in mind when you select a gauge. Avoid the "just-stick-on-a-gauge" attitude. Remember that safety and performance depend on the accuracy — the "honesty"—of that gauge. Remember that your old friend, the pressure gauge, stands between you and trouble.

Those who *do* know the importance of accuracy insist on pressure gauges of Marsh quality. Excellent proof of this is the use of Marsh Gauges as original equipment by leading manufacturers of products requiring pressure indication.*

In the Marsh Masterguage, with its lathe turned bourdon tube and rugged, precision movement, they have found a pressure gauge that will maintain its accuracy year after year under the most arduous service industry knows—extreme pressure, heat, vibration, pulsation. And in all Marsh Gauges, down to the moderately priced Marsh "Standard" Gauges, they have found the same uncompromising quality that has made Marsh Gauges "The Standard of Accuracy."

When you select a pressure gauge—or when you select equipment requiring a gauge—insist on a Marsh. It will stand between you and trouble!



The gauge with the "Recalibrator"

Marsh alone has the "Recalibrator"—quickest and best way to correct a gauge that has been knocked out of adjustment by improper handling.

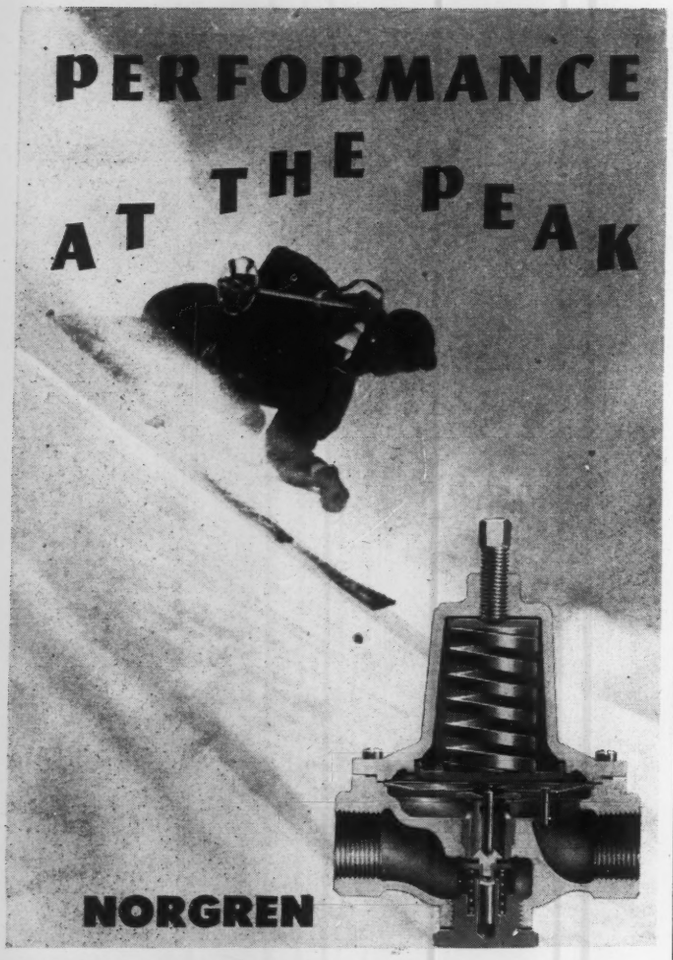
*Subsequent advertisements in this publication will cite typical examples of this.

Jas. P. Marsh Corporation, 2056 Southport Avenue, Chicago 14, Illinois

Jas. P. Marsh products include: A full line and range of gauges in pressure, compound, altitude, hydraulic, sprinkler, ammonia, ounce-graduated retard, test, and diagram types. Dial thermometers in rigid stem and remote reading types. *Ask for literature.*

MARSH GAUGES

"THE STANDARD OF ACCURACY"



REGULATORS hold performance of pneumatic equipment *at the peak* . . . deliver smooth, steady, power-packed air—easily adjusted and accurately controlled for best operation.

Four Basic Points of Norgren Regulator superiority:

(1) Floating Diaphragm cushioned to insure flexibility and long life. **(2) Baffle Plate Action** controls diaphragm, causing more decisive opening and closing of valves and ports; prevents chatter and fluctuation. **(3) Syphon Tube** opens valve faster, permitting larger volume of air to pass with less pressure drop than conventional regulators. **(4) All parts precision machined,** completely interchangeable and easily removed without dismantling or removing valve from air line.

Start right, *use Norgren Regulators.* Write for catalog No. 400. C. A. Norgren Co., 222 Santa Fe Drive, Denver 9, Colorado.

Norgren

ALLEN FLAT HEAD CAP SCREWS

For perfect countersink-fit; positive wrenching — and more!

(1) Flush top surface with no gap between screw head and surrounding metal.

(2) Extreme rigidity of grip, because angle of head helps lock screw in place by drawing down on a conical surface.

(3) Firmer hold on thin plates of metal, by more binding surface under the head than in fillister type or cheese-head screws.

(4) Shallower countersink — less weakening of metal — when used for fastening a relatively thin plate.

(5) Positive engagement of hex key transmits power for tightest of set-ups without slipping, reaming or side play.

(6) Maximum strength of screw itself assured by *"pressur-forming"* of special-analysis ALLENOY steel. Threaded to a high Class 3 fit.

(7) Speed in assembly provided for by use of Allen hand drivers and key blades for power drivers.

Order of your local ALLEN Distributor, — or ask him for samples and engineering data for preliminary try-out. Get *proof* that these screws perform as dependably as Allen Hollow Set Screws and Socket Head Cap Screws.

TRADE MARK

THE ALLEN MANUFACTURING COMPANY
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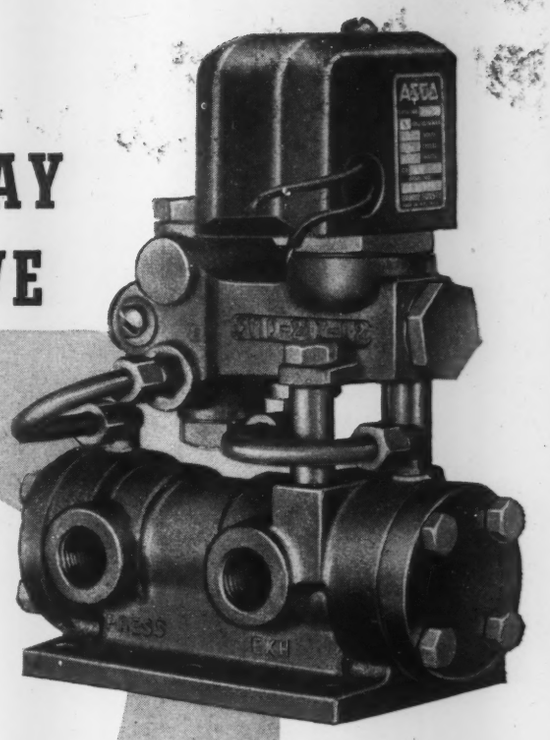
ASCO *announces*

NEW HIGH SPEED 3-WAY SOLENOID CONTROL VALVE



APPLICATION . . .

for air or hydraulic control of single acting cylinders, diaphragm motors, machine tools, etc.

ACTION RANGE . . .

up to 400 complete cycles per minute

PRESSURE RANGE . . .

up to 250 pounds

This latest addition to the ASCO Line of 3-Way Solenoid Valves is available in two sizes—½" or ¾"—screwed connections or with connections in mounting flange. Port size of the valve is full ¾" dia. with 0.30 sq. in. free port area. Valve body is of bronze with stainless steel, bevelled regrinding type seats and discs. Main valve discs are operated by a piston which is controlled by 3-way Solenoid operated pilot valve. The entire construction of this valve is such as to make it rugged, durable and capable of withstanding severe service.

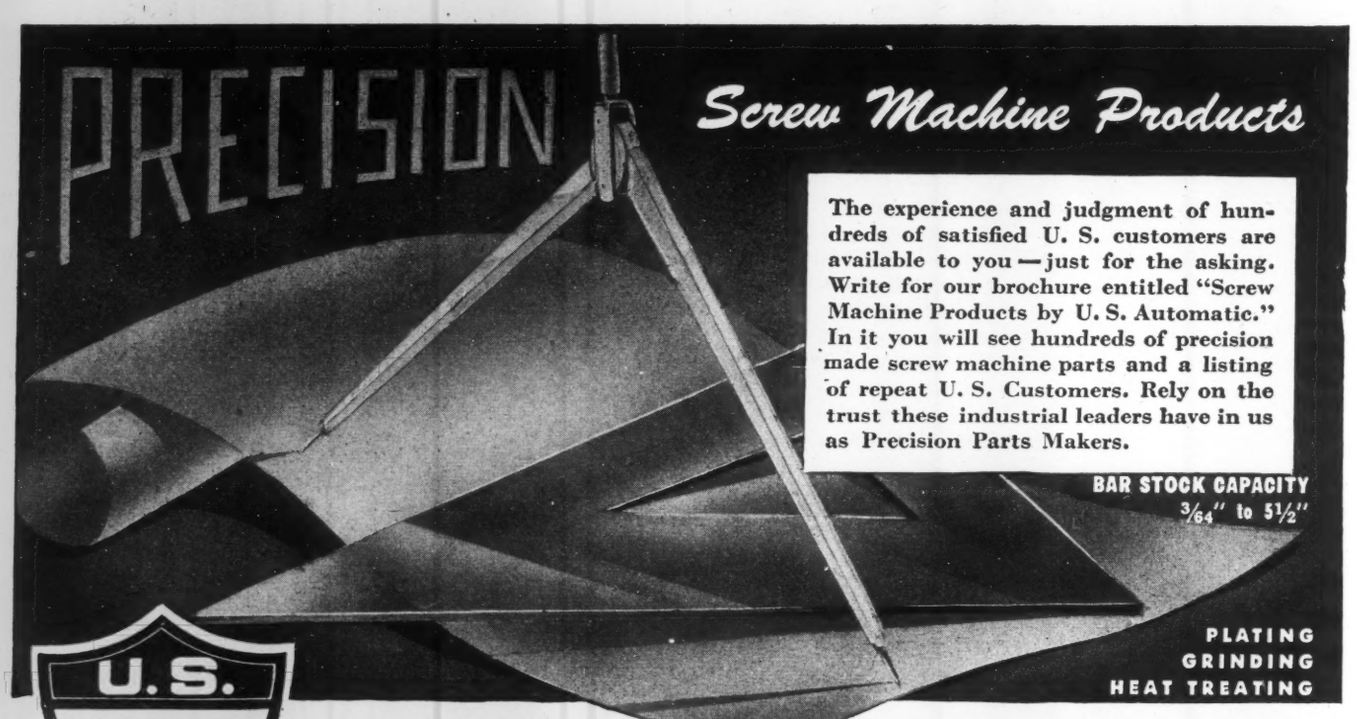
This new ASCO 3-way Valve may be just what you have been looking for to provide better control of the equipment you are manufacturing. Write us in detail and we'll be glad to study your requirements in relation to this new valve. If it isn't suitable, we will be glad to make recommendations based on alternate types in the extensive ASCO Line of Valves.

We also manufacture a quality line of Automatic Transfer Switches, Remote Control Switches, Contactors and Relays

ASCO *Solenoid* VALVES

Automatic Switch Co.

49 East 11th Street • New York 3, N. Y.



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Screw Machine Products AMHERST, OHIO

CHICAGO • DETROIT • INDIANAPOLIS • NEW YORK • PHILADELPHIA • PITTSBURGH

VALVAIR WON'T LEAK AFTER Millions OF OPERATIONS!

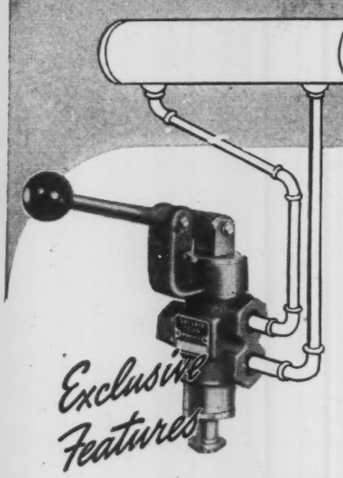


Diagram shows double-acting air cylinder operated by Valvair lever-operated 4-way valve.

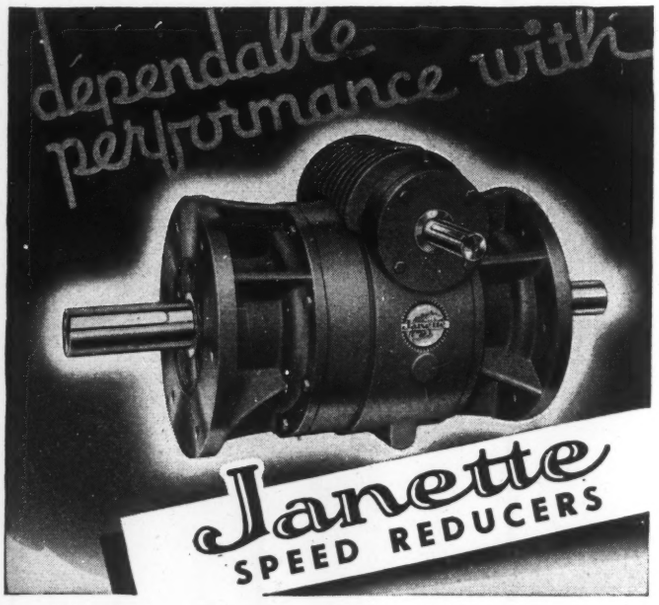
Exclusive Features

Sensational performance? Perhaps; certainly thoroughly proven, thoroughly dependable; over 2,000,000 operations at 100 lbs. pressure and still going strong. Non-corrosive—cast bronze body, stainless steel parts; no metal seats to cause; trouble; full pipe area utilized with minimum pressure drop. *A Valvair for every need:* 3 types, 8 designs, 5 sizes (1/4" to 1").

Ask for our Bulletin "A-D" or a Valvair representative

VALVAIR CORPORATION • 454 Morgan Avenue, Akron 11, Ohio

Valvair



Do You Know . . . JANETTE builds their own motors, brakes, 32 styles and sizes of MOTORIZED and 20 MOTORLESS Speed Reducers. . . Has had 37 years experience in building geared apparatus of the highest quality. . . . Offers manufacturers and users ONE source of supply and ONE responsibility for the successful operation of Janette reducers. 1/30 to 7 1/2 H.P., .08 to 447 R.P.M.

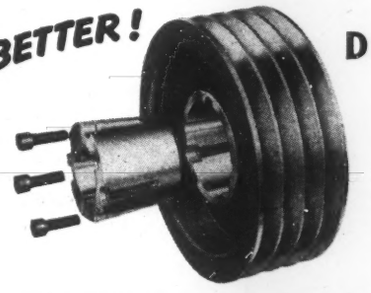
Janette Manufacturing Company
556 W. Monroe St. Chicago 6, Ill.

NEW AND BETTER WAYS OF POWER TRANSMISSION

There are new ways to put more power on the job. Get the facts. Ask the Dodge Transmissioneer to tell you about the latest developments by Dodge of Mishawaka. The Transmissioneer is your local Dodge distributor, listed in the classified telephone directory under "Power Transmission Equipment."

DODGE MANUFACTURING CORPORATION, MISHAWAKA, INDIANA

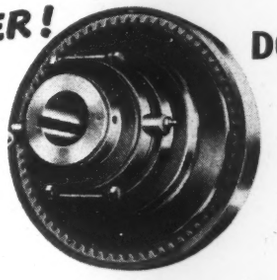
NEW AND BETTER!



DODGE TAPER-LOCK BRAND SHEAVE

An entirely new type of taper bushed sheave—the simplest, surest mechanism ever devised for holding wheels to shafts! No flange. No collar. No protruding parts. Mounts as a complete unit. Breaks all speed records in mounting and demounting—saves time and temper.

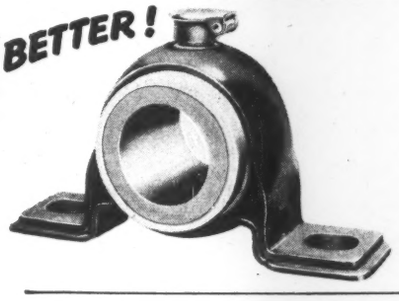
NEW AND BETTER!



DODGE ROLLING GRIP FRICTION CLUTCH

No Toggles! Rugged, compact, easy to adjust. Another great achievement of Dodge Transmissioneering . . . designed to give outstanding flexibility and ease of control without any sacrifice of positive drive . . . and available at low cost! Sizes ½ H. P. to 20 H. P. at 100 R.P.M.

NEW AND BETTER!



DODGE *BronZoil* BEARING

Designed especially for exacting requirements of fan and blower service. Capillary bronze bushing has capacity of one-third its volume in oil. Reservoir and wick provide ample lubrication. Fully self-aligning. Neoprene oil resisting grommets available for noise isolation.

DODGE

MISHAWAKA

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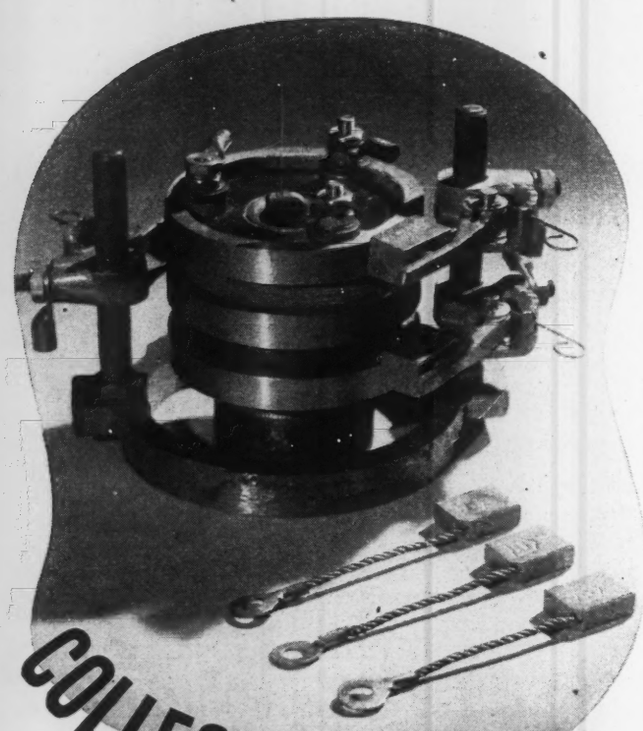
NAME PLATES

FOR YOUR NAME PLATE REQUIREMENTS, WRITE OUR SUBSIDIARY, ETCHING COMPANY OF AMERICA, 1520 MONTANA STREET, CHICAGO 14, ILLINOIS



COLLECTOR RINGS

WELCO Collector Rings are made in all sizes to carry currents of 5 to 200 amperes. Two to twelve rings can be furnished on one stub complete with brush holders, brushes, studs for supporting the brush holders and stud rings. The collector rings can be assembled as a unit on one hollow tube with threads on one end and insulation bushing on the opposite end. The brush holders carrying the current are made of brass. The collector rings are made of hard bronze material. Bakelite insulation is used.

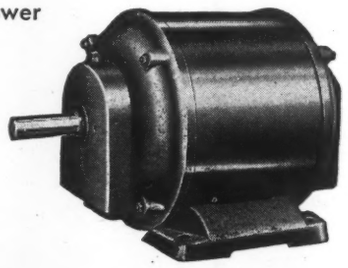
Welco Collector Rings are custom-built to fit the special design and functional requirements of your machines or equipment. A limited number of standard types are available. Send us your blueprints and we will design for you the collector rings that are functionally correct.

THE B. A. WESCHE ELECTRIC CO.
1622-12 VINE ST. CINCINNATI 10, OHIO

Before you specify

ANY MOTOR, *check these* VALLEY *ADVANTAGES*

- ✓ **Wide Adaptability**—sizes ½ to 75 h. p.
- ✓ **More Flexibility** in power planning.
- ✓ **Takes Unusual** Power Loads
- ✓ **Drip-Proof . . .** Splash-Proof
- ✓ **Economical** Operation
- ✓ **Cool**
- ✓ **BALL BEARING**



VALLEY ELECTRIC CORPORATION
4221 Forest Park Blvd. • St. Louis 8, Mo.

COOLANT SERVICE?

Here's Why It Will Pay You To Specify TUTHILL Pumps

For coolant service, you get performance features like these in Tuthill Model M pumps: Positive delivery. Self priming. Built-in automatic by-pass that protects against excessive pressure and allows small particles to pass through without serious injury to working parts. Capacities up to 50 g.p.m. Available in stripped form for direct incorporation into the design of the machine.

Write for Tuthill Model M bulletin

TUTHILL PUMP COMPANY
939 East 95th Street • Chicago 19, Illinois

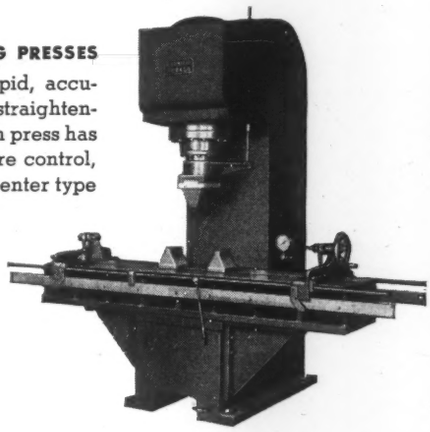
HANNIFIN

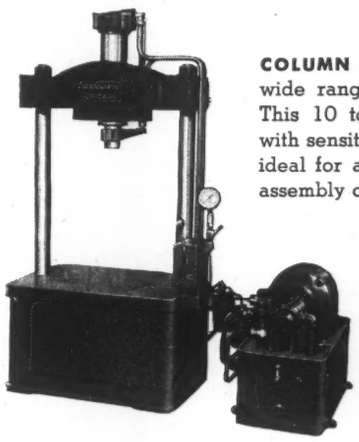
PNEUMATIC AND HYDRAULIC EQUIPMENT

HYDRAULIC PRESSES

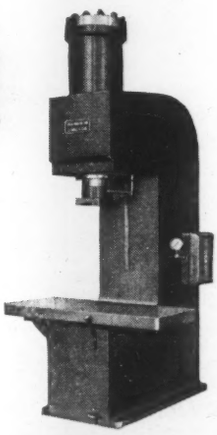
available in 2, 3, 4 column, and open gap types, capacities 5 tons to 150 tons, for straightening, forming, press assembly and similar operations involving the application of pressure. Column spacing, ram stroke, table construction, speeds, and controls may be readily modified to suit individual needs.

STRAIGHTENING PRESSES designed for rapid, accurate production straightening. This 100 ton press has sensitive pressure control, long table and center type fixture.



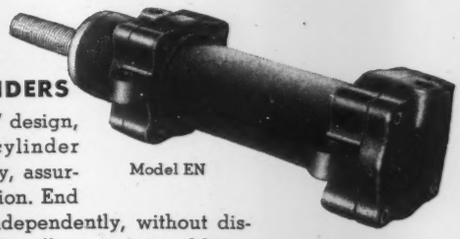


COLUMN TYPE available in a wide range of types and sizes. This 10 ton two column press with sensitive pressure control is ideal for accurate pressing and assembly operations.



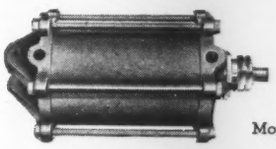
FORCING PRESSES built in many sizes and types, with control and table design to suit individual needs. This 75 ton press has sensitive pressure control and is adapted to general press-fit assembly, forcing and forming operations.

HYDRAULIC CYLINDERS

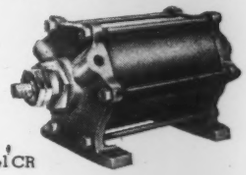


Model EN

with patented "no-tie-rod" design, providing a stronger cylinder assembly, simpler to apply, assuring high efficiency operation. End caps may be positioned independently, without disturbing mounting for simple, efficient piping. Mirror finish honing gives a cylinder bore that is straight, round, perfectly finished. High efficiency piston seal with minimum fluid slip is assured. Seven standard mounting types; special mountings and large sizes built to order.



Model BR



Model CR

PNEUMATIC CYLINDERS

provide simple outside adjustment of the soft piston packing, allowing easy maintenance of the high efficiency piston seal with minimum friction loss. All sizes are bored and honed for straight, round, mirror finish cylinder bore—a better finish that means better cylinder performance. Built in a full line of standard mountings, sizes 1 to 16 inch bore, for any length stroke, with or without cushion.

AIR CONTROL VALVES

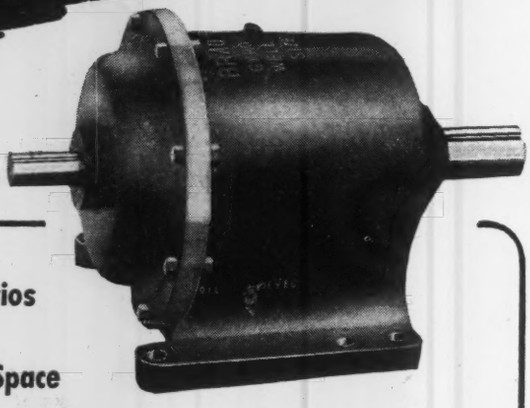
disc type for positive, accurate control of air operated equipment. Efficient disc type design without packing prevents leakage and waste of air power, does away with packing maintenance troubles. The bronze disc controlling air flow is ground and lapped to make a perfect seal with the valve seat. Made in 3-way and 4-way types for control of single and double acting cylinders in hand or foot models, spring return, heavy duty rotary, manifold, and electric models. Also piston type pressure regulating valves.

"HY-POWER" HYDRAULIC RIVETERS

for high speed production riveting, punching, pressing. Portable and stationary types available, designed for easy handling and consistent rapid production. Capacities 7½ to 100 tons. The automatic operating cycle is push-button controlled and includes rapid advance stroke, automatic high pressure working stroke, automatic reversal, rapid return stroke. The hydraulic pressure generator is a compact motor driven unit. "Hy-Power" equipment is adaptable to a wide range of riveting, punching, and pressing operations.

HANNIFIN MANUFACTURING COMPANY • CHICAGO 24, ILLINOIS

The New Gyro SPEED REDUCER



All Ratios in Small Space

24:1 to 3600:1

with

Brad Foote Gears

THE GYRO PRINCIPLE

The BRAD-FOOTE Gyro reducer consists principally of one stationary internal gear — a double spur or combination spur and internal gear mounted on ball bearings on a shaft eccentric to the pitch line of the stationary internal gear. In mesh with the secondary gear is either a spur or internal gear which is solid and concentric with the output shaft — the input shaft is usually travelling at motor speed — forcing the initial spur gear to travel around the pitch line of the stationary internal gear. The initial spur and the secondary gear are solid; therefore, the speed of the secondary gearing is controlled by the ratio between the initial spur gear and the stationary internal gear.

To obtain large ratios between a spur gear and an internal gear, there must be a very small difference in the number of teeth between the spur gear and the internal gear; therefore, the Brad-Foote Gear Works take advantage of the eccentric lever — the mechanical leverage involved is the ratio between the eccentric radius and the pitch line radius of the stationary internal gear times the leverage of the eccentric radius to the radius of the pitch line of the output gear.

As mentioned before, to get large ratios we have a small difference in number of teeth between the spur and internal gear, making the pitch line of the spur gear to almost conform to the pitch line of the internal gear, thus engaging a large number of teeth — thereby getting away from concentrated loads on a single tooth as is the case in ordinary gear type reducers. In this type of gearing at least 16% of the total number of teeth are wholly or partially engaged.

All moving parts are mounted on antifriction ball or roller bearings — longer life of the gears are possible because of larger number of teeth in mesh — there is no concentrated tooth load on any one tooth and due to the number of teeth in mesh makes it possible for the unit to have a greater torque capacity for a given size case than many other reducer types.

Details and Prices on Request

Send for Catalog

BRAD-FOOTE GEAR WORKS

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The FLEX V TRADE-MARK Belt Fastener for A and B Belts of open end construction

Size No. A180 for A Belts
Size No. B214 for B Belts

Flex V fasteners are made in two sizes for joining A and B V-belts of special open-end cross-woven fabric construction and on drives rated as light duty with a belt speed of not over 3000 feet per minute. The fasteners must not be used on heavy duty or high speed drives or for joining or repairing V-belts that were originally endless.

Flex V fasteners are easy to apply with the special applicator tool. The separable hinge joint makes for quick replacement of V-belts without dismantling shafting or machinery. Flex V fastened V-belts can also be run on V Flat Drives for there is no metal on the under side of the belt to contact the flat faced pulley.

Folder No. V-12 gives complete details on this Flex V fastener with list prices, special tools and application information. Your request will bring a copy.

Order from your supply house

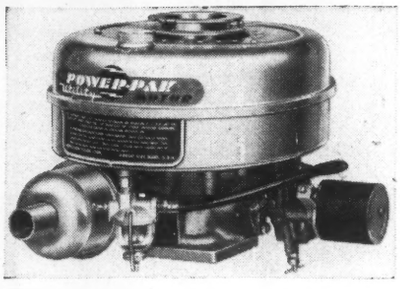
FLEXIBLE STEEL LACING CO.

4686 LEXINGTON ST., CHICAGO 44, ILLINOIS

Also sole manufacturers of Alligator Steel Belt Lacing for flat transmission belts. Alligator V-belt Fasteners for V-belts and Flexco HD Belt Fasteners and Rip Plates for fastening and repairing conveyor belts.

Power It with... POWER-PAK GASOLINE UTILITY MOTOR

- 2 hp. at 4000 rpm.
- Precision-Built
- Light Weight
- Compact
- Rugged



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*H*ere's a modern-to-the-minute, precision-built, gasoline motor especially fitted to the needs of industrial designers and manufacturers making machines and equipment requiring 2 H. P.

POWER-PAK is compactly designed, light weight (only 19 lbs.), every piece and part of finest materials to insure long, smooth, trouble-free operation. Overall length 14¾", width of cowling 9½", height 8¼". Easily installed . . . economical on fuel . . . easy access to all vital parts. Replacement parts always in stock. Let POWER-PAK solve your power problem.

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PROPULSION ENGINE CORP.

Dept. 1075 7th and White Eagle Road Kansas City, Kans.

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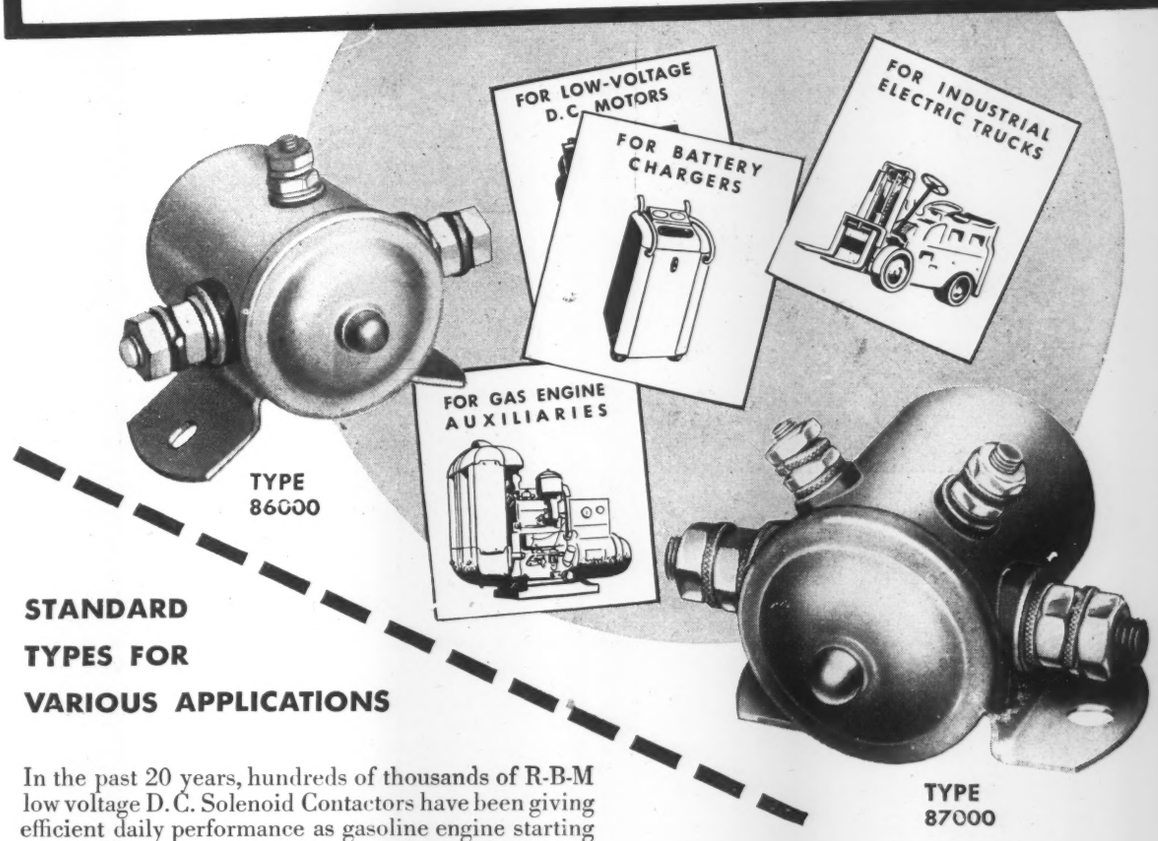
SOLENOID CONTACTORS



STANDARD TYPES FOR VARIOUS APPLICATIONS

In the past 20 years, hundreds of thousands of R-B-M low voltage D.C. Solenoid Contactors have been giving efficient daily performance as gasoline engine starting contactors—battery charging contactors—low voltage D.C. motor controls—auxiliary contactors for industrial electrical trucks—and on mobile and stationary gasoline engine driven apparatus of all kinds.

R-B-M Solenoid Contactors can be furnished with insulated coil terminals or with one insulated coil terminal; the other coil lead may be grounded or connected to the line terminal. All types can be supplied with either flat or curved mounting bracket.

Contacts are single pole, normally open, double break rated at 100 amperes continuous inductive load; or 300 amperes in-rush at 6 volts D.C. and at 50 amperes continuous inductive load or in-rush at 32 volts D.C. Copper contacts are standard, though special alloys are available. Coils are available from 6 to 32 volts D.C. continuous or intermittent duty.

For further information, write for Bulletin 520. Address Dept. H.

R-B-M DIVISION
ESSEX WIRE CORPORATION
Logansport, Indiana

KINNEY

INTERCHANGE CLUTCH

The Kinney Interchange Clutch starts this rugged W. W. Sly Tumbling Mill smoothly and positively . . . allows maximum slippage while picking up the load, without lowering the capacity when fully engaged. With power controlled by the Kinney Clutch, machine life is lengthened, a smaller motor is used and safe operation is assured. The clutch shifts easily since the friction plates are brought together by a rugged toggle mechanism . . . drive is transmitted directly through flat discs and not through bolts or engaging mechanism.

The Kinney Interchange Clutch is available in solid or split construction for easy installation; capacity 2 to 40 H.P. per 100 R.P.M. Write for Catalog K-8 describing the full line of Kinney Clutches.

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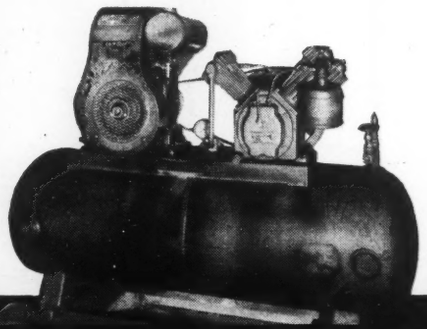

WISCONSIN HEAVY DUTY *Air-Cooled* ENGINE Helps to Supply Air for C&O Railroad Blue Ridge Tunnel Job

This single cylinder heavy-duty Wisconsin Air-Cooled Engine is operating a H-42-DG, Type 30 Ingersoll-Rand Air Compressor which furnishes starting air for the XVO Compressor Unit on the C & O Railroad's Blue Ridge Tunnel Job, near Afton, Virginia . . . handled by contractors Bates & Rogers, Chicago. This is just another run-of-the-mill Wisconsin Air-Cooled Engine construction service application . . . typical of the many heavy-duty power jobs entrusted to these tough, hard-hitting engines on a great variety of equipment in many fields. Wisconsin Air-Cooled Engines are supplied in 4-cycle single cylinder and 4-cylinder V-type models in a power range of 2 to 30 hp.

Specify "WISCONSIN" for utmost dependability and heavy-duty serviceability.

Most H.P. per pound

WISCONSIN MOTOR Corporation

MILWAUKEE 14, WISCONSIN, U. S. A.

World's Largest Builders of Heavy-Duty Air-Cooled Engines

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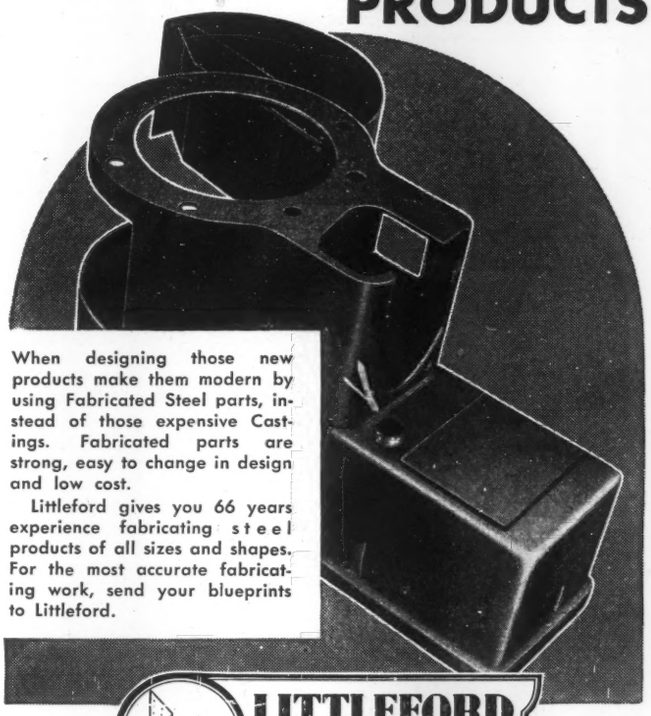

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For maintaining an accurate, uniform rate of flow regardless of variations in pressure of hydraulic fluid ... **water, gasoline** and other **petroleum products,** coolants.

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To maintain flow rate for proportioning of different fluids.

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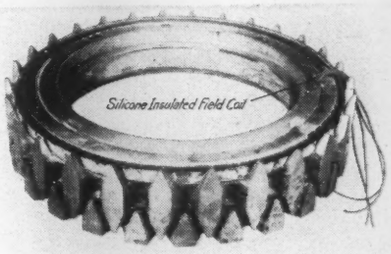
Silicone News

DC SILICONES

DC Silicone Insulation Extends Life of Electro-magnetic Brake



PHOTO, COURTESY DYNAMATIC CORPORATION, SUBSIDIARY OF EATON MANUFACTURING COMPANY

Protects water cooled field coil in this magnetic field member.

In producing electro-magnetic brakes for well drilling rigs, the Dynamatic Corporation, of Kenosha, Wisconsin, tested and adopted DC Silicone Insulation. Moisture infiltration limited the life of coils treated with organic varnishes. Protected by DC 996, none of these coils has failed.

These brakes exert a variable and controllable retarding effect without friction or wearing parts. Fundamentally, they involve the rotation of an iron drum through a variable magnetic field created by stationary coils inside the drum. Eddy currents generated in the rotating drum exert on the rotor a torque which varies with the amount of current admitted to the field coils.

A heavy duty model absorbs up to 5,000 horsepower, providing speeds from 800 r.p.m. down to a rate that permits the setting of slips on the heaviest strings of drill pipe.

The permanently sealed field coils are cooled by water circulating over the field casting and eddy current members. But DC 996 excludes moisture indefinitely even at high operating temperatures. Insulation resistance remains high despite long exposure to weather when a rig is idle. And, when drilling is resumed, this resistance rises rapidly and soon reaches infinity.

DC 996 is described in leaflet No. B 3-4.

NOTE: See our Exhibit at the Electrical Engineering Exposition, New York, January 27 to 31.

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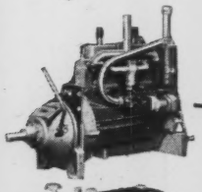
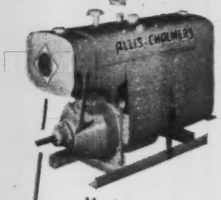
Many different models and sizes of Allis-Chalmers engines and tractors to choose from, with accessories to fit the application.



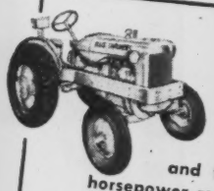


★ POWER UNITS

Designed for tough tractor service, high in torque, A-C heavy-duty power units provide rugged power for every type of job, steady or intermittent. Available in open or enclosed styles, with various accessories. Choice of fuels — gasoline, low-grade fuel, natural gas or butane.

FIVE SIZES

Model	Cylinders	Max. Brake HP.	R.P.M.
B-15	4	24	1500
W-25	4	31.5	1300
U-40	4	45	1200
E-60	4	74	1050
L-90	6	110	1050



★ WHEEL TRACTORS

Popular, economical Allis-Chalmers wheel tractors provide mobile power you can depend upon, at the drawbar or power take-off. Available in 4-wheel and tricycle designs. Various speeds and horsepower ratings. Mounted on rubber tires. Electric starting and lights, other accessories as desired. Gasoline, kerosene, or distillate.

FIVE MODELS

Model	Drawbar HP.	Max. Speed MPH	Max. Belt HP.	R.P.M.
IB	13.5	10.0	16.3	1400
B	13.5	10.0	16.3	1400
C	13.5	7.06	23.3	1500
WF	23.7	9.77	29.93	1300
WC	23.7	9.77	29.93	1300

★ CRAWLER TRACTORS

Powerful, smooth-operating, these A-C 2-cycle Diesel crawler tractors hang onto overloads with the tenacity of steam power. Operate on ordinary Diesel fuels, require less gear shifting, start instantly. Positive seal truck wheels and idlers require lubrication only once in 1000 hours.

FIVE MODELS

Model	Drawbar HP.	Max. Speed MPH.	Max. Belt HP.	R.P.M. at Max. Torque
HD-5	37.04	5.47	45.10	800-1200
HD-7	60.10	5.00	71.08	800-1200
HD-10	86.63	6.03	101.62	800-1200
HD-14	132.19	7.00	150.48	800-1200
HD-14C	*	7.13	*	800-1200

*Torque Converter

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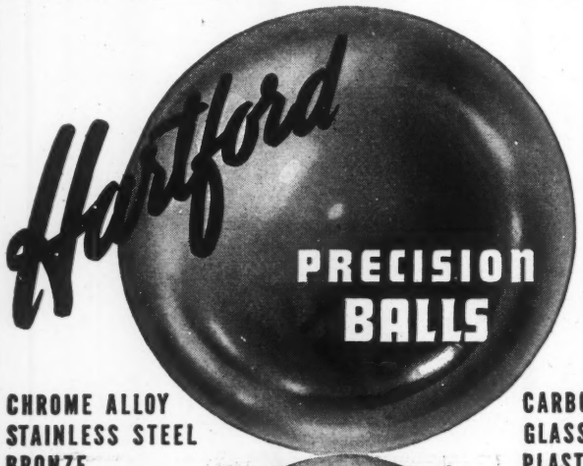

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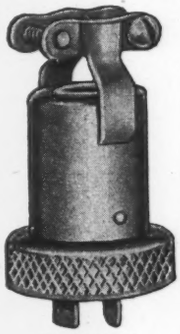
Low loss Plugs and Sockets suitable for high frequency circuits. Ideal for antenna connections, photo-cell work, microphone connections, etc. Supplied in 1 and 2 contact types.

P-101-¼"

The 101 Series can be furnished with ¼", .290", 5/16", 3/8" or ½" ferrule for cable entrance.

Knurled nut securely fastens units together. All metal parts are of brass plated to meet Navy specifications.

No. 101 Series Plugs have ceramic insulation and Sockets have XXX Bakelite.

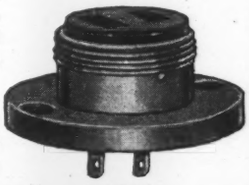


P-202-CCT

S-101

No. 202 Series Plugs and Sockets have BM 120 molded Bakelite insulation.

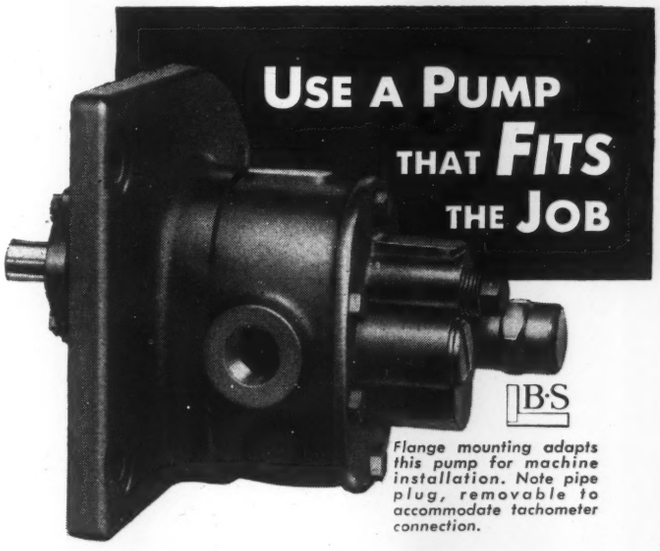
For complete listing write today for your copy of catalog No. 14.



S-202-B

HOWARD B. JONES DIVISION
CINCH MFG. CORP.
2460 W. GEORGE ST. CHICAGO 18

USE A PUMP THAT FITS THE JOB



B·S

Flange mounting adapts this pump for machine installation. Note pipe plug, removable to accommodate tachometer connection.

Frequently it takes a special pump to fulfill installation requirements satisfactorily. Special drives, integral or flange mountings, multiple outlets, dual services and other special adaptations solve many perplexing pump problems. This service is described in our pump catalog. Copy on request. Brown & Sharpe Mfg. Co., Providence 1, R. I., U. S. A.

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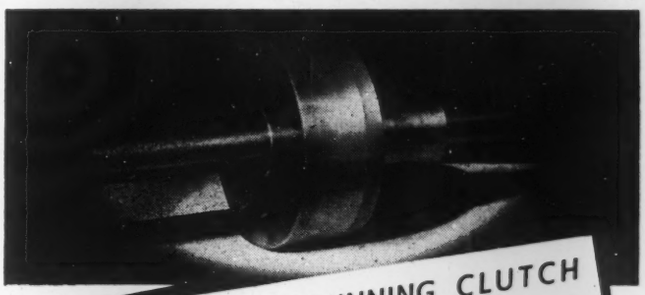
BROWN & SHARPE PUMPS

Clutches by HILLIARD

HILLIARD CLUTCHES AND COUPLINGS
ARE EXCELLENT FOR ALL CLASSES OF MACHINERY



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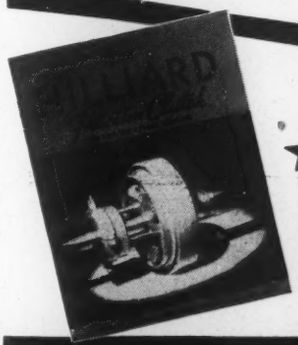
A "Free Wheeling" Clutch of simple design recognized for many years as "Standard Equipment" for Automatic Dual Drive operation – Automatic operation of 2 Speed drive – As a ratchet permitting infinite adjustment and as an automatic backstop. Furnished in a number of types.

HILLIARD SINGLE REVOLUTION CLUTCH

Wherever extremely accurate control of intermittent machine operation is essential the Hilliard Single Revolution Clutch is unequalled. Its accuracy has won for it the acceptance of Industry for cutting, punching and packaging operations.



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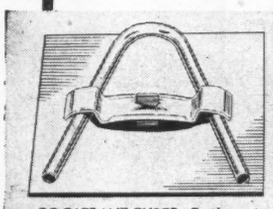

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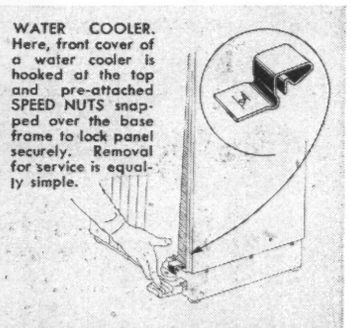

WATER COOLER. Here, front cover of a water cooler is hooked at the top and pre-attached SPEED NUTS snapped over the base frame to lock panel securely. Removal for service is equally simple.

Engineers, who perform seeming miracles every day, are fast becoming fastener conscious. For, with improved fasteners, assembly is made faster and less costly. Fewer parts are used. Weight is reduced. And—that old bugaboo, "vibration loosening" is licked.

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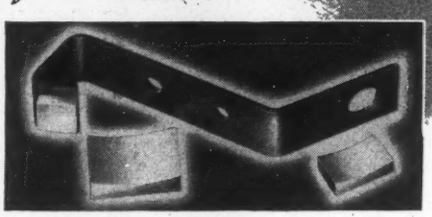

ABOVE: Contact assembly for circuit breaker, with Gibsiloy C5 contact brazed to copper support. BELOW: Gibsiloy C5 sliding contacts.

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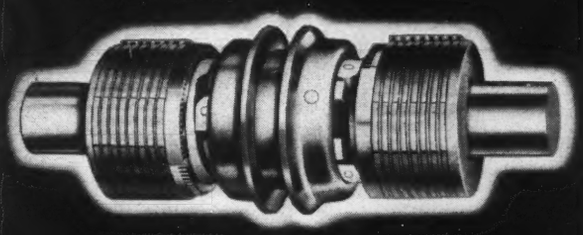

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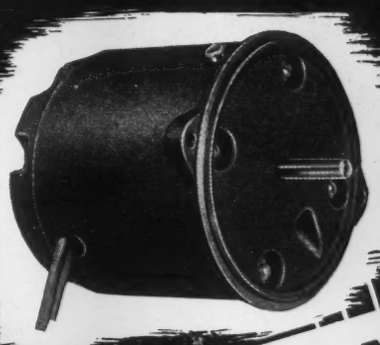

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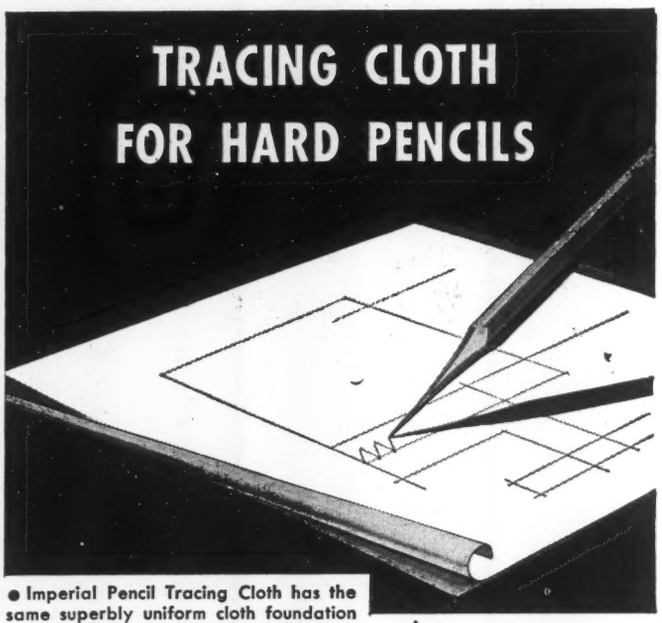

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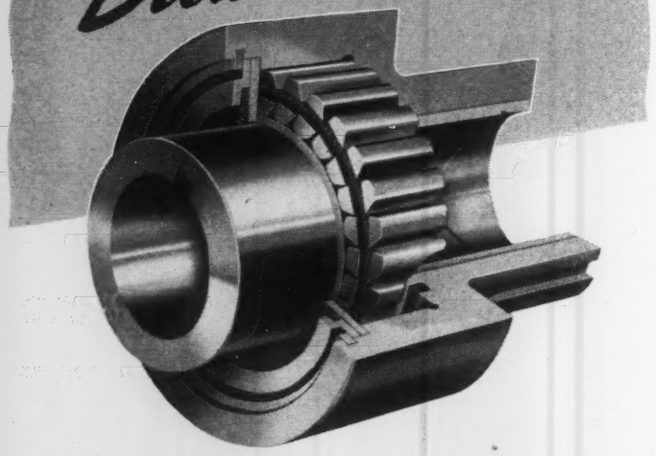

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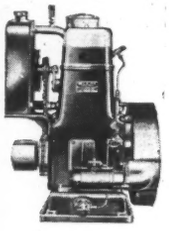

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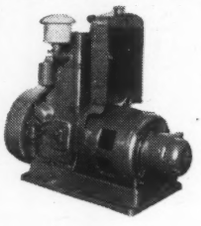

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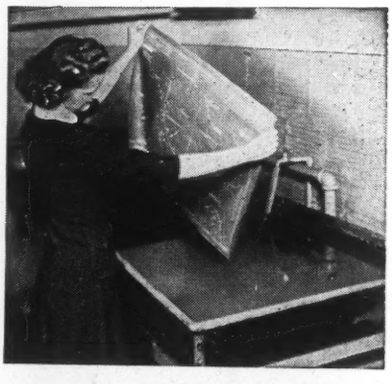

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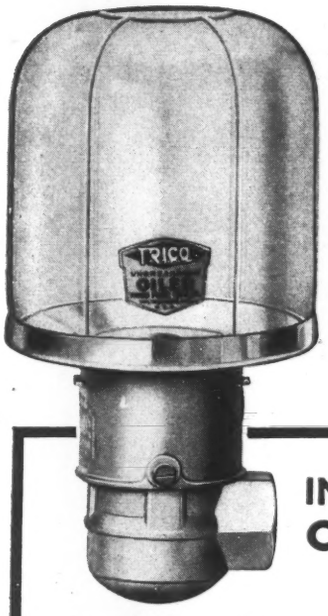

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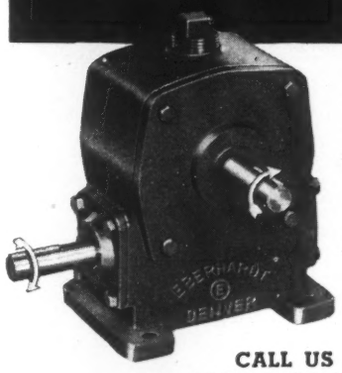

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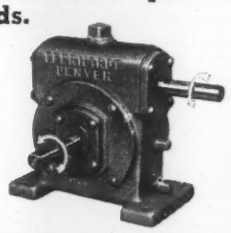

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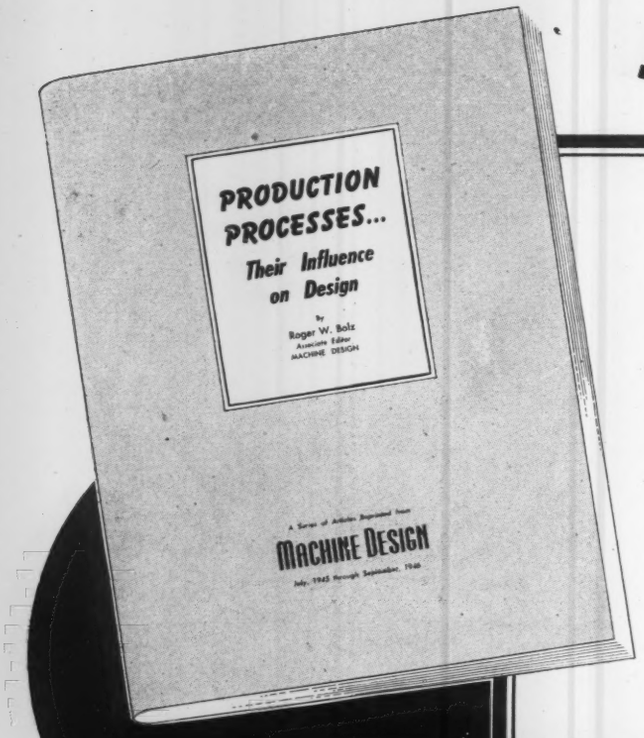

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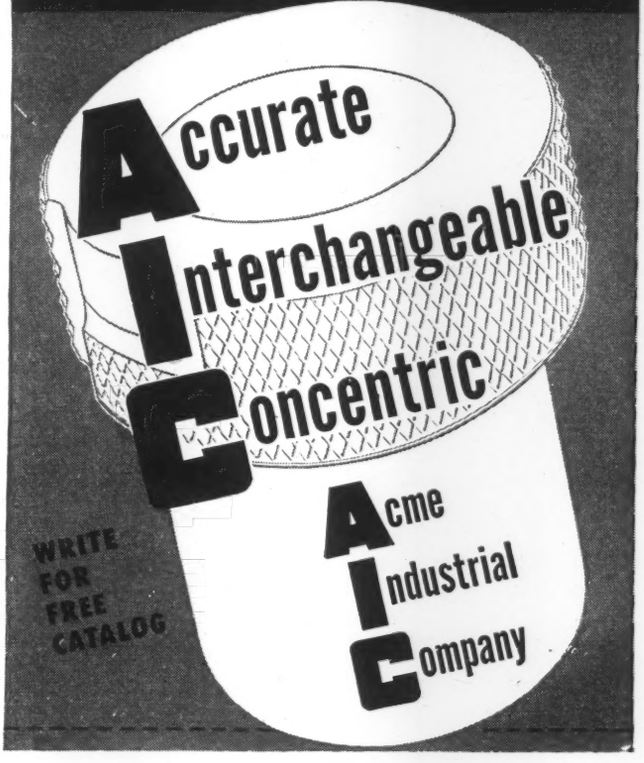

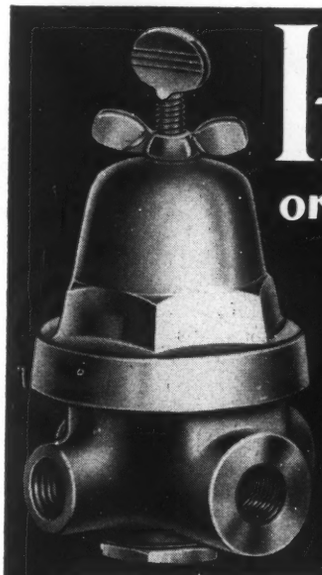

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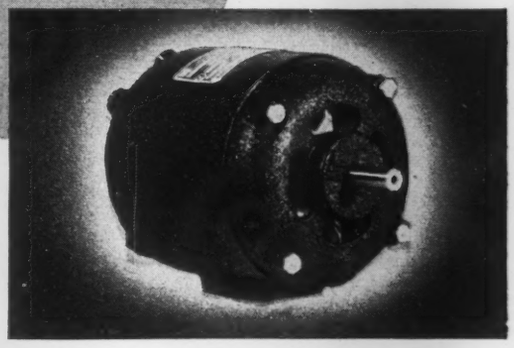

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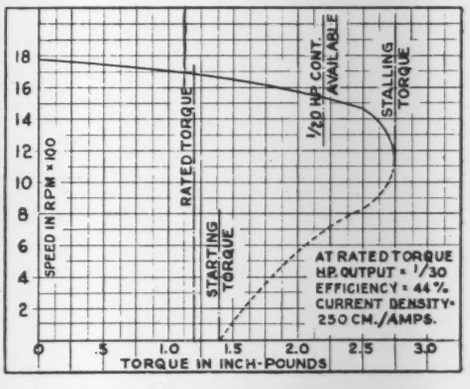

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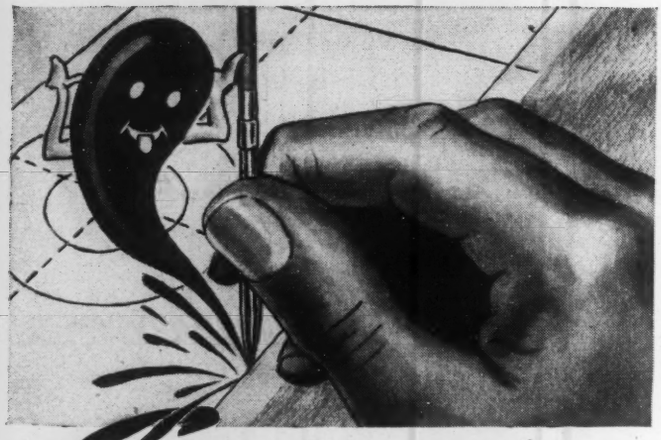

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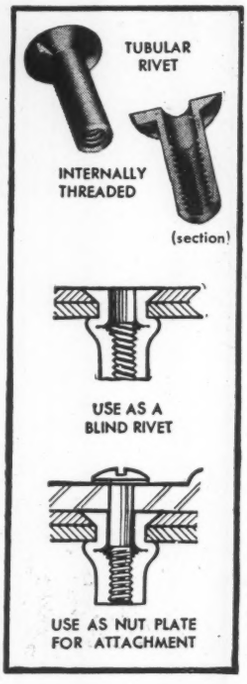

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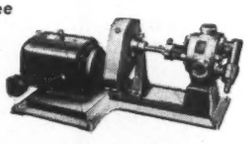

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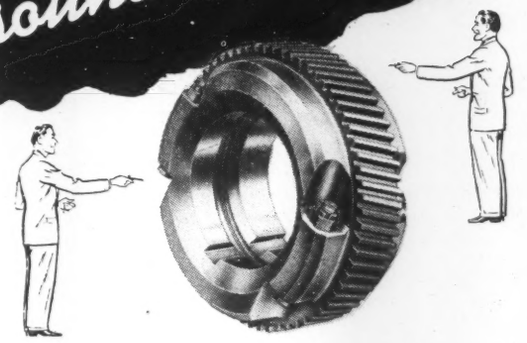

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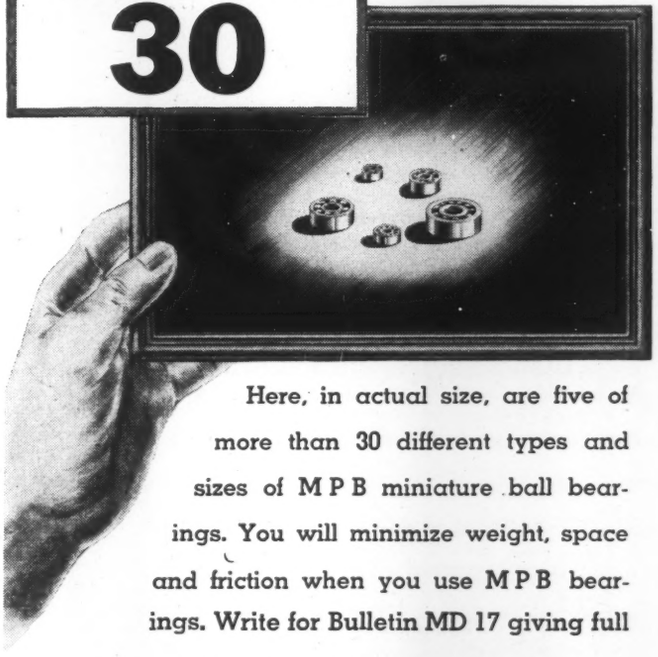

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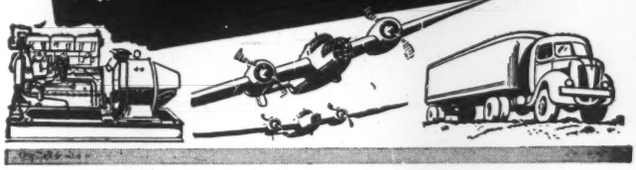

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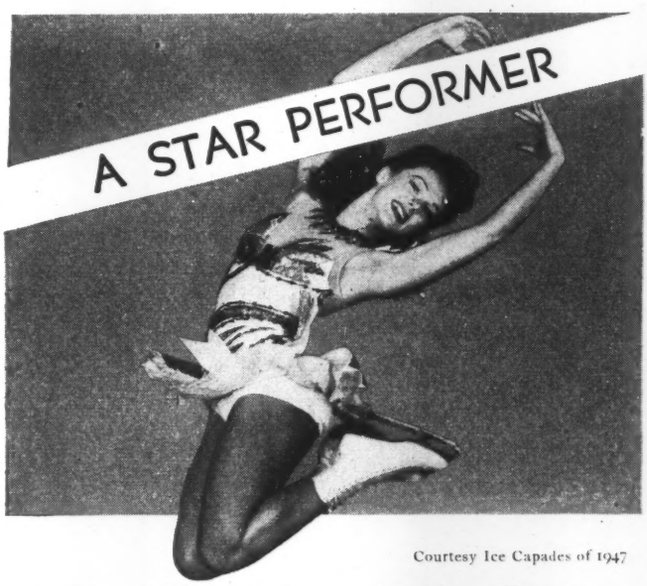

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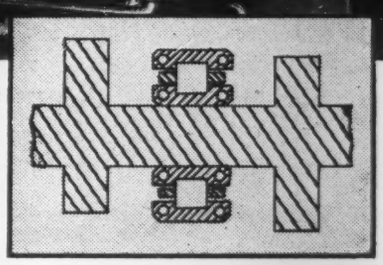

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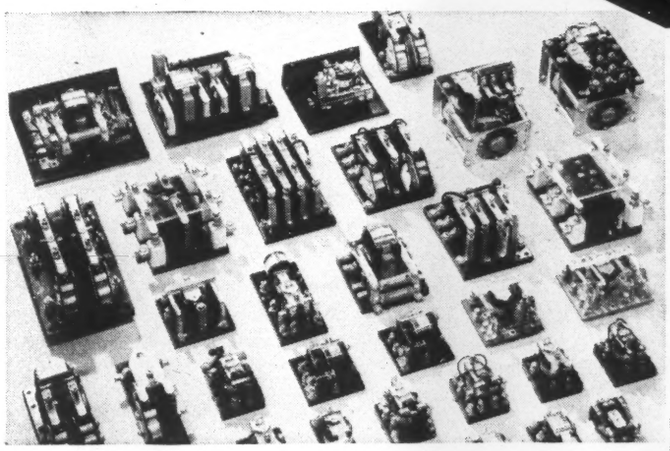

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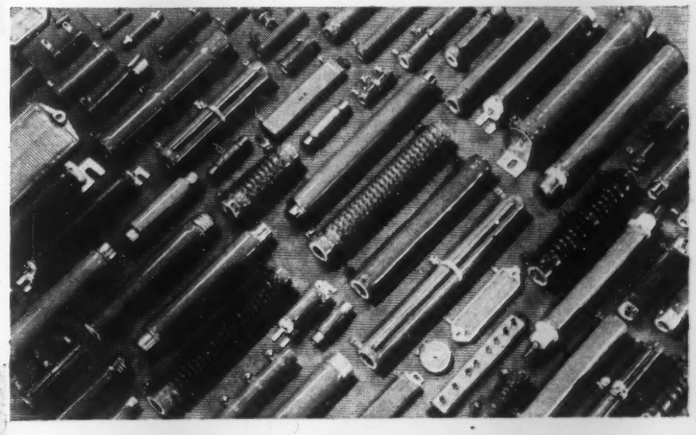

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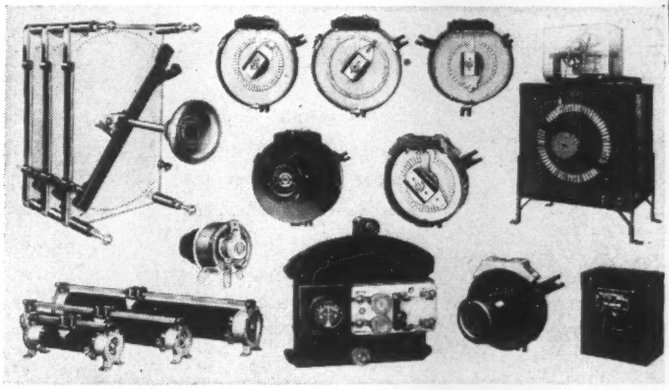

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		100 to 500#	Medium
		500# and up	Hard
	Chrome	Up to 100#	Soft
		100 to 500#	Medium
		500# and up	Hard
Water, above 160° to 200° F.	Chrome Flexotype	All pressures	Soft
		Up to 100#	Medium
		100 to 500#	Hard
		500# and up	Soft
Valves, elevators, cylinders with portholes Auto lifts, gasoline pumps	Chrome	Up to 100#	Medium
		100 to 500#	Hard
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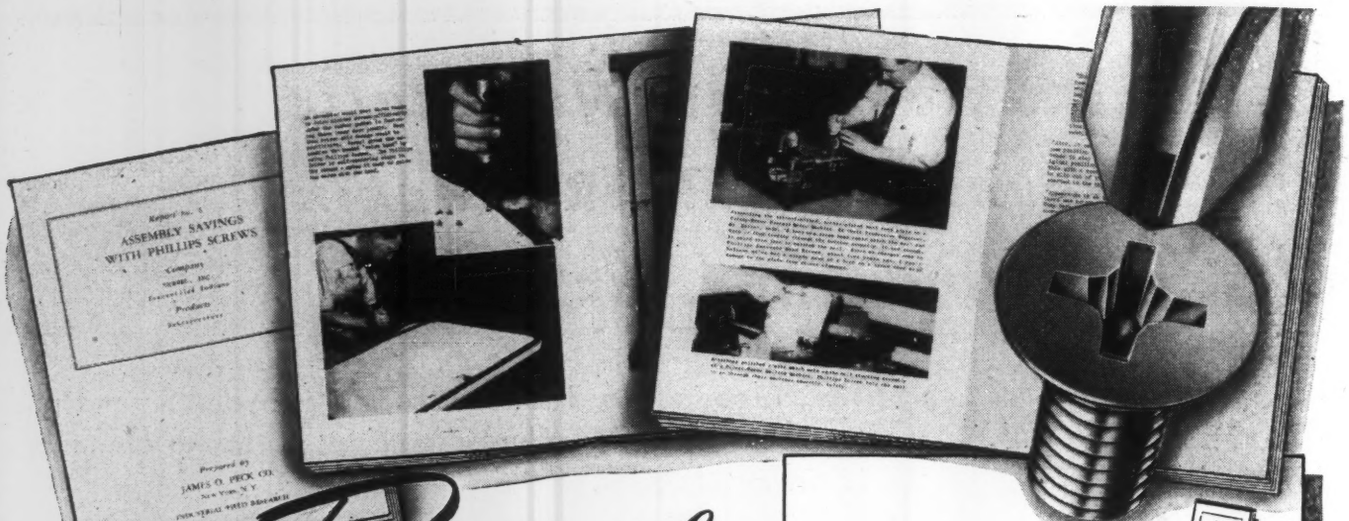

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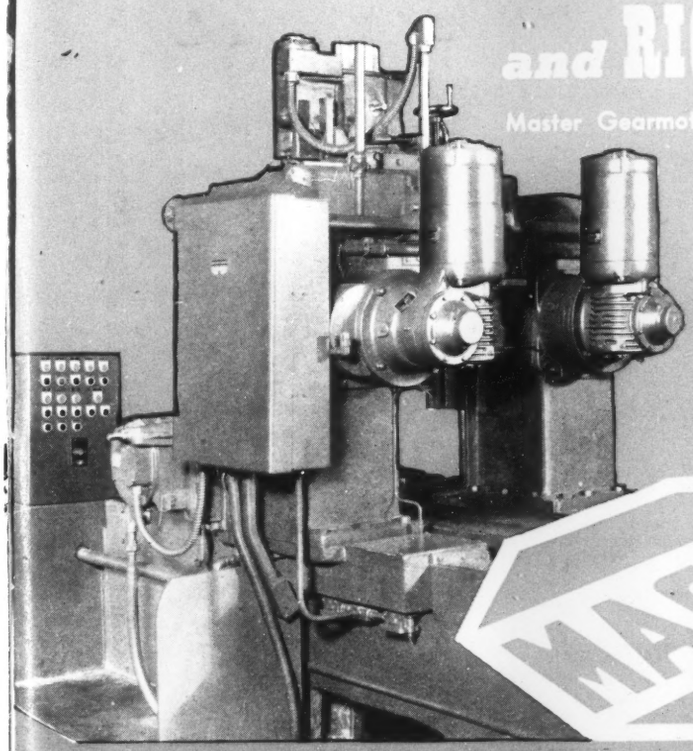

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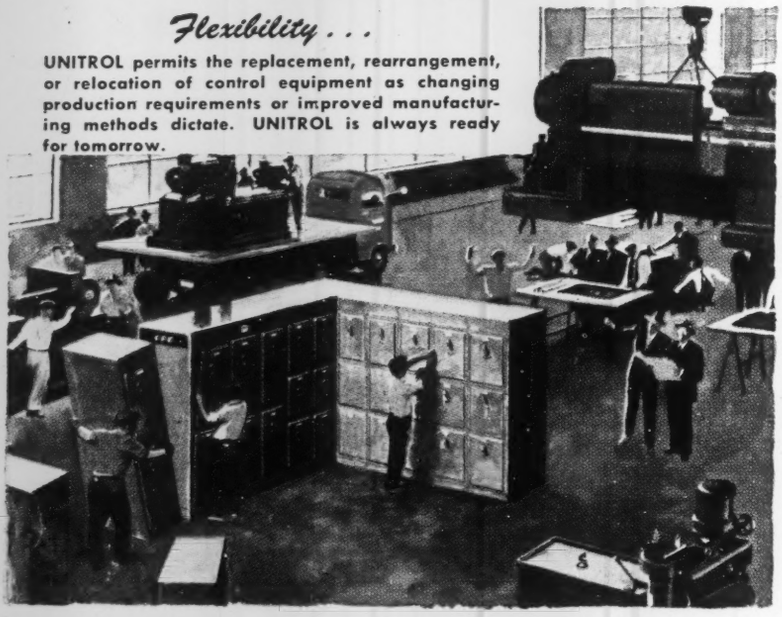

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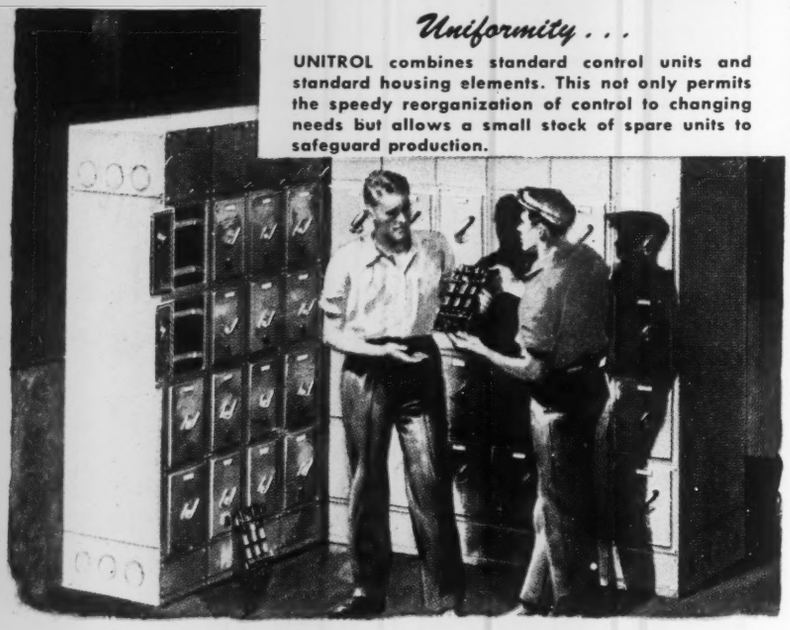

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